ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See page 17, Dec. 5. 7263

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Specification and Workmanship equal to Main Line Locomotives.
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See page 18, Dec. 5. 7454

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See Advertisement page 107.

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See Advertisement page 28. 7268

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are foremost as fire fighters. No Acids. No Alkalis. Safe to use and always ready.—BRITISH FIRE APPLIANCES Co., Ltd., 109, Victoria St., London, S.W. 1.

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Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4535

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See Advertisement page 57, Dec. 5. 2402

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See half-page Advertisement page 98, Nov. 28.

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The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.

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The Institute of Cost and Works Accountants

(Limited by Guarantee).

Donington House, Norfolk Street, Strand, London, W.C. 2.

President:—

The Right Honourable Lord Leverhulme.

An Inaugural Meeting

will be held on Wednesday, December 17th, 1919 (at Seven p.m.)

at the Hall of the Institute of Chartered Patent Agents, Staple Inn Buildings, Holborn, W.C. 2.

Chairman:—Sir Robert Hadfield, Bart., D.Sc. F.R.S.

Speakers:—W. Howard Hazell, Esq., J.P., Henry W. Allingham, Esq., M.I.M.E., M.A.S.M.E.

Admission by ticket only, which can be obtained from the Secretary at the above address. C 308

The National Foremen's Association of the Engineering and Allied Trades.

(Registered under the Trade Union Act.)

An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. A 830

All communications to— H. W. Rhid, General Secretary. Head Offices— 81, High Holborn London, W.C. 1.

Polytechnic, Regent Street, W.

Polytechnic Engineering Society.

Old Members of above Society

are invited to the 31st Annual Conversazione, to be held on Friday, December 19th. Reception by the President at 7.45 p.m.

Hon. Sec., A. Jansen. C 169

Inst. C.E. Exams.—Over 300

successes by Correspondence Coaching. Several prizes. Sec. "D" now prepared. (Designs, Specifications and Quantities). A few vacancies open.—Address, 7434 Offices of Engineering.

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Land Surveying.—Courses

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Inst. C.E. & Inst. Mech. E. Exams

—A Practical Engineer, A.M.I.C.E., &c. (recently demobilised), has now resumed coaching for above by Correspondence, after 11 years' highly successful pre-war experience. Separate subjects may be taken. Excellent testimonials. Fees moderate.—C 90, Offices of Engineering.

TENDERS.

ABERTILLERY & DISTRICT WATER BOARD

POWER PLANT AND MACHINERY.

The above Board are prepared to receive

Specifications and Tenders for

the supply and erection of the following power plant and machinery, to be used in the construction of their Grwyne Fawr Reservoir Works:—

1. No. 2 GENERATOR SETS, each consisting of gas engine, with suction gas plant, starter and cooler, driving No. 1 300 B.HP. dynamo, D.C. 500 volt.
   Or alternatively, "DIESEL" ENGINES complete, driving similar dynamos.
2. No. 2 CABLE-WAYS with travelling head and tail towers, electrically driven, working load 5 tons on maximum span of 1,100 ft.
3. No. 2 STONE CRUSHERS, electrically driven, with motors, screens and elevators.
4. No. 1 set of STONE CRUSHER and SAND ROLLS, electrically driven
5. No. 2 Half-yard CONCRETE MIXERS, electrically driven, complete with hoppers and water tanks.
6. No. 1 Double-caged CONCRETE HOIST, with tipping bucket, electric hoisting motor, receiving hoppers, main and auxiliary chutes complete.
7. No. 2 ELECTRIC TRAVELLING CRANES, capacity 3 to 4 tons at 40 ft. radius.
8. No. 1 STEAM TRAVELLING CRANE, capacity 5 tons at 50 ft. radius.
9. No. 1 AIR COMPRESSOR with electric motor, capacity 500 cubic feet, free air per minute, with air receiver complete.

Further particulars can be obtained from the Board's Engineer, Mr J. Francis Jupp, M.Inst. C.E., Midland Bank Chambers, Bridge Street, Newport, Mon.

The Board do not bind themselves to accept the lowest or any tender.

9th December, 1919. C 245

The Governors of the South-Western Polytechnic Institute, Chelsea, S.W.3, invite

Offers for the Purchase of a

compound tandem horizontal drop valve steam engine, by Easton and Bessemer, Taunton, 100 H.P., Cylinders 9 in. by 15 in. with 24 in. stroke, complete with surface condenser, throttle and expansion governors, speed changing device for speeds between 40-120 revs. Suitable for an educational institution. The Governors do not bind themselves to accept the highest or any Offer. C 107

MUNICIPAL COUNCIL OF JOHANNESBURG.

Contract 962.

Sealed Tenders, endorsed

"Contract 962" will be received by the Town Clerk, Tender Box, Municipal Offices, Johannesburg, not later than 12 noon, 9th February, 1920, for

NORTHERN EXTENSION OF REFRIGERATING PLANT, ABATTOIRS.

Drawings and Documents can be viewed at the Council's London Agents, Messrs. E. W. Carling & Co., St. Dunstan's Buildings, St. Dunstan's Hill, London, E.C. 3, and copies obtained on deposit of £2 2s.

The lowest or any Tender will not necessarily be accepted.

G. S. Burt Andrews, Town Engineer.

Johannesburg, 1st Nov., 1919. C 203

SIAMESE STATE RAILWAYS.

Tenders are requested for the

Supply of 31,977 Metric Tons of STEEL RAILS and PERMANENT WAY ACCESSORIES. Specifications and drawings may be obtained, against payment of £1, from Messrs. C. F. Sandberg, 40, Grosvenor Gardens, London, S.W. 1.

Sealed Tenders with the inscription "Tender for Steel Rails and Accessories B.R. 2462," must be forwarded to the undersigned, at whose office they will be received up to 2 o'clock p.m. on the 31st January, 1920.

(Sgd.) Purachatra, General.
Commissioner-General of Siamese State Railways, Bangkok, Siam.
25th September, 1919. C 188

G. R.

The Admiralty have for Disposal H.M. PADDLE MINESWEEPER "CROXTON,"

particulars of which are as follows:—

Builders—
Ayrshire Dockyard Co., Ltd.
Hull—
Steel. Two complete Steel Decks.
Dimensions—
235 ft. B.P. by 29·1 ft. M.B. by 9·2 ft Mld. depth to lower deck.
Extreme breadth over paddle boxes 58 ft.
Gross tonnage 737·4.
Engines—Inclined Compound.
Boilers—Two Cylindrical Howden's draught. W.P. 125 lbs. per sq. in.
Speed—15 knots.

Tender forms with permission to inspect may be obtained from the DIRECTOR OF CONTRACTS, Branch 8, Room 80, West Block, Admiralty, London, S.W. 1.

Tenders will be received up to 12 o'clock noon on Monday, 29th December, 1919. C 44

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD. (Plant and Machinery Section.)

For Sale, by Public Tender,

CHEMICAL PLANT.

Continuous Plant for the Production and Rectification of Sulphuric Ether, each producing 20 tons of rectified ether at 65° per 24 hours.

Six Ether Equipments of 21,000 kgs. and various Accessories. The apparatus installed in two separate structures, forming two groups of three equipments each. Production of one group 120,000 kgs.

The above plant is in first-class condition, and is lying in cases unpacked at H.M. Factory, Henbury.

Tenders close January 6, 1920.

WOOD LEAD-LINED TANKS.

Sizes varying between 3 ft. 11 in. by 3 ft. 2 in. by 3 ft. 2 in. and 10 ft. 6 in. by 10 ft. 6 in. by 4 ft.

Lying at H.M. Factory, Litherland. Ref. G.88.

Tenders close January 6, 1920, at 10 a.m.

MISCELLANEOUS PLANT.

Lying at Farina Mills (Altdon Hill), Bradford, Lincoln.

Potato Washing Machines, Hydro Extractors, Friction Sack Hoist, Tanks of various sizes, Offal Press, Potato Receiving Reel, Fibre Extractors, Oak Cleansing Vats, Sirrocco Fans, Potato Breakers, Three-tier Steam Jacketted Worms, Potato Grinders, Disc Feeders, Double Dryer Conveyor, Steel Hand Packing Cylinders, Pipes, Shafting, Pulleys, Belting and other Accessories.

Tenders close 10 a.m., January 3rd. Ref. G 1735.

WOOD DISTILLATION PLANT.

From H.M. Factory, Carmarthen, stored at H.M. Factory, Mid-Lavant, Ludlow, Longparish and Bideford. Plant comprises the following:—

Sets of Retort Platework, complete with doors and frames; Retort Condensers, Tar Separators, Roots Blowers, Traversers, Smoke Consuming Apparatus, Winches, Copper Vapour Pipes, Corwood Cars. Copper Seals for Tar Separators, and other Accessories.

Tenders close January 6th, 1920. Ref. G. 408.

Full particulars of the above, together with Tender Forms and permit to view can be obtained on application to the CONTROLLER, D.B.I.e., Charing Cross Embankment Buildings, W.C.

Note.—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 2s., post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. C 268

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—

	Fee for Specification.
Steel Rails	£1
Cast Iron Pot Sleepers	£1
Copper Rods	10/-
Acid Open Hearth Steel Boiler Plates	7/6
Firebricks and Fireclay	7/6

Specifications and Forms of Tender may be obtained at this Office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned marked "Tender for Steel Rails," or as the case may be, not later than Eleven o'clock a.m., on Wednesday, the 31st December, 1919.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. Walpole, Secretary.

Company's Offices, 48, Copthall Avenue, E.C. 2. London, 10th December, 1919. C 266

APPOINTMENTS OPEN.

A Large Firm of Engineers

in the Midlands have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4359, Offices of Engineering.

INSTITUTE OF INDUSTRIAL ADMINISTRATION.

(Trustees—Pending Incorporation—
H. S. B. Brindley and R. T. Elbourne).

Lecturers Required in London

and Provinces to give short evening courses of practical instruction in special subjects. Gentlemen having the necessary experience in works administration—technical, labour and commercial—who are prepared to consider undertaking educational work of this character, are invited to communicate with HON. SEC., Institute of Industrial Administration, 110, Victoria Street, S.W. 1. C 306

NORTHAMPTON POLYTECHNIC INSTITUTE,

260, St. John Street, London, E.C. 1.

CIVIL AND MECHANICAL ENGINEERING DEPARTMENT.

ELECTRICAL ENGINEERING AND APPLIED PHYSICS DEPARTMENT.

Applications are Invited for

an additional ASSISTANT LECTURER and DEMONSTRATOR in each of the above departments. Commencing salary according to qualifications and experience, £235 to £315, rising afterwards to a maximum of £400 or £450.

Particulars and forms of application can be obtained from C 246

R. Mullinhux Walmsley, D.Sc., Principal.

BIRMINGHAM MUNICIPAL TECHNICAL SCHOOL.

Applications are Invited for

a LECTURESHIP in MECHANICAL ENGINEERING. The appointment is on a salary scale of £180 rising to £360. The commencing salary offered will be dependent upon the experience of the applicant. In addition to the salary there is at the present time a War allowance of £74 to £78 per annum. Full particulars may be obtained on application to the SECRETARY, Municipal Technical School, Suffolk Street, Birmingham. C 160

Applications are Requested

for the following APPOINTMENTS in INDIA:—

(1) ENGINEER-SALESMAN, having engineering training, and if possible some Sales Experience for the Sales Department of Firm manufacturing railway material.

(2) ENGINEER-DRAUGHTSMAN for designing and detailing light Railway Wagons, track work and Structural Material.

(3) OFFICE-MANAGER, having sound experience in Book-keeping, Costing, and general routine work of an engineering manufacturing firm.

Applicants should be well educated, single, preferably not over 30. Engagement will be for a term of three years, with progressive salaries.—Address, "R.E.D.," Box 3054, Leathwait & Simmons, 5, Birchin Lane, E.C. 3. B 898

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Principal—James G. B. Edwards, A.M.I.M.E.

The Governors invite

Application for the following

Post:—

(1) Teacher of Engineering Subjects. Commencing salary £350 per annum with increment, according to the new scale (under revision).

Candidates should have a University Degree, or the equivalent, and workshop experience.

Application forms, which should be returned not later than December 20th, may be obtained from R. Dempsey, Clerk to the Governors, 1, Selborne Road, Walthamstow. C 257

ROYAL TECHNICAL INSTITUTE, SALFORD.

Principal—B. Prentice, D.Sc., Ph.D.

Applications are Invited for

the POST of HEAD of the Mechanical Engineering Department. Candidates should possess a University Degree or its equivalent, and have had workshop experience. Previous teaching experience and laboratory practice essential. Salary scale £450 to £650. The commencing salary will be fixed according to qualifications and experience.—Further particulars and forms of application may be obtained from the SECRETARY, Education Office, Chapel Street, Salford. Last day for application, Tuesday, 6th January, 1920.

L. C. Evans, Town Clerk. C 223

GLOUCESTERSHIRE COUNTY COUNCIL.

MAIN ROAD SURVEYORS.

Applications are Invited on

or before the 30th December, 1919, for TWO APPOINTMENTS to the POSITION of MAIN ROAD SURVEYOR under the Council. Applicants must have served overseas in the late war, and be trained civil engineers with road experience.

Age not to exceed 36 years.

Salary £300, with £80 per annum allowance for motor bicycle and sidecar.

Forms of application and details of duties may be obtained from

COUNTY SURVEYOR, Shire Hall, Gloucester. C 198

UNIVERSITY OF MANCHESTER (Faculty of Technology).

MANCHESTER MUNICIPAL COLLEGE OF TECHNOLOGY.

APPOINTMENT OF SENIOR LECTURER IN MECHANICAL ENGINEERING.

The City Council and the University of Manchester jointly invite

Applications for the Senior

Lectureship in Mechanical Engineering with the title and status of Reader in Applied Thermodynamics in the University of Manchester and in the College of Technology.

Salary £600 per annum.

Conditions of appointment and form of application may be obtained from the Registrar, College of Technology, Manchester. The last day for the receipt of applications is Thursday, 15th January, 1920.

Canvassing, either directly or indirectly, will disqualify a candidate for appointment. C 279

SHANGHAI MUNICIPAL COUNCIL.

CIVIL ENGINEER AND ARCHITECT.

The Shanghai Municipal Council

Requires the Services of a

CIVIL ENGINEER AND ARCHITECT, to take charge of constructional work required by the Electricity Department, chiefly in connection with the Power Houses, Sub-stations and building work generally.

Experience in steel-work construction and reinforced concrete work, especially foundations, essential.

Thorough technical education and practical experience necessary. Preference will be given to applicants who have passed the examination for Assoc. Members of the Inst. Civil Engineers or equivalent examination.

Salary, 800 taels per month. Free passages and free medical attendance. The usual rate of exchange for a tael is about 3s., the present rate of 7s. 4d. is abnormal.

First engagement three years.

Applications, stating age and full particulars of training and experience, together with recent testimonials, to be sent to Messrs. Preece, Cardew, Snell & Rider, 8, Queen Anne's Gate, Westminster, S.W. 1, not later than Thursday, January 1st, 1920. C 256

Superintendent.—Chief

Assistant wanted for Electrical Switchgear Department of large Engineering Works. Applicants only considered who have had experience in modern factory methods and possess a good technical training. To a man of initiative and energy the position holds good prospects.—Address stating experience (fully), age, and salary expected, B 917, Offices of Engineering.

TRACTOR AND COMMERCIAL VEHICLE ENGINES.

Assistant Test Inspector

required for Petrol and Paraffin Engines as above. Must have had good previous experience in this line. Preference given to one of about 30 years of age with good education and address. State age, full experience and salary required.—Address, C 81, Offices of Engineering.

Metallurgical Chemist Re-

quired by modern engineering firm to take full charge of Chemical and Physical Laboratories and Pyrometric and Micro Photographic Depts., dealing with ferrous and non-ferrous materials, including high speed and alloy steels. A good salary will be paid to a suitable man. Apply, giving full particulars of training, experience, references, age and salary required.—Address C 167, Offices of Engineering.

Wanted, Assistant Chemist

in Laboratory, with experience in analyses of blast furnace materials and products. Must be a good man.—Apply stating age, qualifications, experience and salary required, to ASSISTANT MANAGING DIRECTOR, The Stanton Ironworks Company, Ltd., nr. Nottingham. C 67

Foundry Manager—Capable

man required to take charge of the Foundries of a modern Engineering Works. Output 50-60 tons per week. The position offers plenty of scope for suitable man.—Address, giving full particulars of experience, age, salary required, and references, C 28, Offices of Engineering.

Works Management.—A

large Electrical Engineering firm have a VACANCY for an ASSISTANT to supervise the manufacture of large electrical machinery, and invite applications from those with executive ability, a thoroughly practical workshop experience and technical training, knowledge of modern methods of quick production, and used to control. The position offers good prospects to a suitable man. Applications (in confidence) should state age, past experience and positions held, and salary required.—Address, C 34, Offices of Engineering.

Wanted, Assistant Technical

MANAGER for London Office of firm specialising on condensing plant and engine room auxiliaries. Principal duty will be correspondence re sale of marine auxiliaries. Must have had previous experience and be known to shipowners and superintendent engineers. Applications will be treated as strictly confidential.—Address, giving particulars of experience and salary required, C 272, Offices of Engineering.

THE ST. CYR AERODYNAMIC BALANCE FOR TESTING MODEL PROPELLERS.

By WILLIAM KNIGHT.

THE wind tunnel of the St. Cyr Aerodynamic Institute, which was recently re-designed at the French Technical Section of Military Aviation, will allow, it is hoped, after the transformation of the present installation, a wind speed of approximately 200 km. per hour, or 182 ft. per second, in the cylindrical section 2 m. diameter by 6 m. long, which is the maximum wind speed obtained, so far in a tunnel of these dimensions. In connection with the re-designed tunnel, a new aerodynamic balance was designed for measuring the air resistance on aeroplane parts (models of wings, aeroplane bodies, &c.), placed into the wind stream. The balance was designed for measuring a maximum drag force of 10 kg. and a maximum lift force of 100 kg.

A detailed account of the transformation work of the St. Cyr wind tunnel and of the design of the aerodynamic balance, on which I worked while I was attached to the Experimental Division of the French Technical Section of Military Aviation, is given in two previous reports that I made on those subjects.

The design of an aerodynamic balance for testing models of aerial propellers in the new tunnel was the next problem investigated at the French Technical Section of Aviation. The fundamental considerations which we were guided by in the design of that balance were the following:—The law of similitude as affecting the relations between the results derived from model propellers and those to be anticipated from full-sized propellers imposes the restriction: $\frac{V}{N\,D} = \frac{v}{n\,d}$, where V = the velocity of the air in the direction of the axis of the rotation of the full-sized propeller; v = the velocity of the air in the direction of the axis of rotation of the model propeller; D = diameter of full-sized propeller; d = diameter of model propeller; N = unit number of revolutions of full-sized propeller; n = unit number of revolutions of model propeller. This relation implies that the two propellers are operating under equal slip, or, otherwise, that the ratio between the circumferential velocity at the tip of the blade and the speed of advance is the same in each case.

We will assume that the air resistance on any element of a propeller blade can be expressed under the form: KSV^2 — where K is a function of the shape of the element considered, and consequently is the same at any two corresponding points of two geometrically similar propellers.

For two propellers geometrically similar, the ratio $\frac{V}{N\,D}$, which depends on the angle of incidence of the blades, is the same if the angle of incidence of both the full-sized propeller and the model propeller tested, is always the same at any two geometrically similar points of the two propellers.

We will call $\frac{D}{d} = \lambda$; $\frac{V}{v} = \mu$; $\frac{F}{f}$ = ratio of the thrust exerted by the two propellers. $\frac{C}{c}$ = ratio of the two couples. $\frac{P}{p} = \frac{F\,V}{f\,v}$ = ratio of the useful work done by the two propellers. The force F, the couple C and the power P can be expressed under the form:

$$\left.\begin{aligned} F &= \alpha\,N^2\,D^4 \\ C &= \beta\,N^2\,D^5 \\ P &= \beta\,N^3\,D^5 \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (1)$$

where α and β are two functions depending on the value of $\frac{V}{N\,D}$ only.

The efficiency of the propeller, or the ratio between the useful power (or, power realised in forward movement of the aeroplane) and the effective power (power delivered to, or absorbed by, the propeller) can be expressed:—

$$\rho = \frac{V}{N\,D}\,\frac{\alpha}{\beta}$$

Our problem was: knowing $\lambda = \frac{D}{d}$ what is the value of v, and what the value of n that should be adopted in order to have the same values of α, β and ρ for the model propeller tested and for a geometrically similar propeller λ times larger.

It could easily be proved that the angles of incidence of the blades of the two propellers are the same, first, if $\frac{N}{n} = \frac{\mu}{\lambda}$; and, second, if μ is taken such that for any two corresponding points of the propellers, the angle through which the blade is deformed under the influence of both the centrifugal force and the aerodynamic force, is the same. We will find what the value of μ needs to be in order to satisfy this second condition.

We will consider the two propellers at an instant when the blades of the two are parallel to each other; considering the two elementary surfaces = ds and dS of two parallel blades located at a distance δ and Δ respectively, from the two axes of rotation, and calling v_1 and V_1 the resultant of the air velocity in the direction of the axis of rotation and the peripheral velocity of the two points considered:

$$V_1 = \sqrt{V^2 + (\pi\,N\,\Delta)^2};\quad v_1 = \sqrt{v^2 + (\pi\,n\,\delta)^2}$$

the resistance opposed by the air to the displacement of the two elementary surfaces considered is given by $K \times dS \times V^2$, and $K \times ds \times v^2$, respectively. These two forces are parallel and their ratio is: $\frac{dS}{ds} \times \frac{V^2}{v^2}$. The ratio of the two geometrically similar surfaces dS and ds, is equal to λ^2. The ratio

$$\left(\frac{V_1}{v_1}\right)^2 = \left(\frac{V}{v}\right)^2 = \mu^2$$

and the ratio of the two forces given above will be equal to: $\lambda^2\,\mu^2$

The centrifugal forces acting at the two points considered having masses M and m respectively, will be parallel, and their ratio will be:—

$$\frac{M\,\Omega^2\,\Delta}{m\,\omega^2\,\delta} = \frac{M\,(\pi\,N)^2\,\Delta}{m\,(\pi\,n)^2\,\delta}$$

The ratio of the two geometrically similar masses considered is equal λ^3; the ratio $\frac{\Delta}{\delta} = \lambda$, and the ratio $\frac{N}{n}$, we have seen before, must be equal to $\frac{\mu}{\lambda}$ Substituting in the formula given above, the ratio of the centrifugal forces acting on the points considered of the two similar propellers is given by: $\lambda^2\,\mu^2$, the same as we found when we considered the ratio of the aerodynamic forces acting on the two propellers. The resultants of the aerodynamic forces and the centrifugal forces acting on the two masses M and m, which represent the thrust exerted by those elements of the two propellers will also be parallel and their ratio: $\frac{dF}{df}$ will also be equal to $\lambda^2\,\mu^2$

The formulae giving the elastic deflection of a body, show that the deflection is proportional to the force acting on the body, is proportional to the cube of the lever arm, and is inversely proportional to the moment of inertia of the section. If we call ϕ the deflection at the point M and ψ the deflection at m and assume that the two similar propellers are made out of the same wood, we will have:

$$\frac{\phi}{\psi} = \frac{dF}{df}\left(\frac{\Delta}{\delta}\right)^3 \frac{I}{i}$$

where I and i are the moments of inertia of the two blade sections. Substituting

$$\frac{dF}{df} = \lambda^2\,\mu^2;\ \left(\frac{\Delta}{\delta}\right)^3 = \lambda^3;\ \frac{I}{i} = \frac{1}{\lambda^4}$$

in the above formula we will have:—

$$\frac{\phi}{\psi} = \lambda^2\,\mu^2\,\lambda^3\,\frac{1}{\lambda^4} = \lambda\,\mu^2,$$

Calling Γ and γ, respectively, the angles of rotation of the two blades corresponding to the deflection ϕ and ψ, it will be seen that the ratio of the two angular displacements $\frac{\phi}{\Delta}$ and $\frac{\psi}{\delta}$ of the points M and m can be expressed like this:—

$$\frac{\phi}{\Delta} : \frac{\psi}{\delta} = \frac{\phi}{\psi} : \frac{\Delta}{\delta} = \frac{\Gamma}{\gamma}$$

Substituting:

$$\frac{\phi}{\psi} = \lambda\,\mu^2,\ \frac{\Delta}{\delta} = \lambda$$

we will have:

$$\frac{\Gamma}{\gamma} = \frac{\lambda\,\mu^2}{\lambda} = \mu^2$$

So that we arrive at the very important conclusion that, in order to have equal angles of distortion, $\Gamma = \gamma$ for the model propeller tested, and the full-sized propeller, we must have

$$\mu^2 = 1, \text{ or } V = v \quad . \quad . \quad . \quad (2)$$

In order to have equal angles of incidence for the two blades, we have seen before that we must also have:

$$\left.\begin{aligned} n &= \lambda\,N \\ d &= \frac{D}{\lambda} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (3)$$

These conditions being satisfied, we will have:

$$\frac{v}{n\,d} = \frac{V}{N\,D}$$

The angles of incidence of the two propellers will be the same, and, consequently, the functions α and β and the efficiency ρ as obtained from the model propeller, will be the same for the model propeller and the full-sized propeller.

The ratio of the thrusts, of the couples, and of the works of the two propellers will be equal to, respectively:

$$\left.\begin{aligned} \frac{F}{f} &= \frac{\alpha\,N^2\,D^4}{\alpha\,n^2\,d^4} = \left(\frac{\mu}{\lambda}\right)^2 \lambda^4 = \lambda^2 \\ \frac{C}{c} &= \frac{\beta\,N^2\,D^5}{\beta\,n^2\,d^5} = \left(\frac{\mu}{\lambda}\right)^2 \lambda^5 = \lambda^3 \\ \frac{P}{p} &= \frac{\beta\,N^3\,D^5}{\beta\,n^3\,d^5} = \left(\frac{\mu}{\lambda}\right)^3 \lambda^5 = \lambda^2 \end{aligned}\right\} \quad . \quad . \quad (4)$$

since in every case $\mu = 1$.

These conclusions are accepted by Eiffel, by Toussaint, and other French writers. The conclusions arrived at are based on the assumption that the aerodynamic force on a propeller blade is of the form $K\,S\,V^2$, which is not strictly exact, although nearly true. So far, however, we do not know definitely of any better law of variation of the force with the velocity, and we will accept it as it is.

It should be pointed out that the co-efficient K increases with S, and consequently the K of the full-sized propeller is likely to be larger than the K of the model propeller, and, such being the case, the air velocity v adopted for the small propeller should be rather larger than the velocity V of the full-sized propeller, depending on the law of variation of K with S, which is to be established by experiments.

The propellers used at the present time on aeroplanes are about 10 ft. in diameter and develop a maximum power of from 300 h.p. to 500 h.p. at a speed of rotation of about 1,500 r.p.m., and at a velocity of flight of about 180 ft. per second; the propeller thrust may be as much as 450 kg.

In the St. Cyr tunnel, 2 m. in diameter, the maximum diameter of the model propeller tested will be 1 m. in diameter. Model propellers 1 m. in diameter can easily be made perfectly similar to full-sized propellers about three times larger, and we may expect, by using large models, to be able to obtain more reliable experimental data. A propeller having a diameter 50 per cent. of the diameter of the experimental chamber of the tunnel, it is believed, will not give rise to any turbulent motion of the air stream around the edges of the blades; this means that we may have $\frac{D}{d} = \lambda = 3$. Such being the case, we had to design the balance such as to give:

$$n\ (\text{max.}) = N\,\lambda = 1{,}500 \times 3 = 4{,}500 \text{ r.p.m.}$$

$$p\ (\text{max.}) = \frac{P}{\lambda^2} = \frac{500}{3^2} = 55 \text{ h.p.}$$

$$f\ (\text{max.}) = \frac{F}{\lambda^2} = \frac{450}{3^2} = 50 \text{ kilog.}$$

Two aerodynamic balances already built for testing model propellers were considered at that time; the balance used by Dr. Durand at the laboratory of the Leland Stanford Junior University, and the balance used by Colonel Crocco of the Italian Army, at the Central Aeronautic Institute at Rome. The Crocco balance was found to be more readily adapted to our needs, and I went to Rome

to investigate the design of the balance and the principle on which the design was based.

A fundamental difference in the interpretation of the relation existing between results derived from model propellers and full-sized propellers exists between the Italians and the French. The French method, as we have seen before, adopts as a limiting condition that the angle through which the blades are deflected at any two points m and M of the model propeller and the full-sized propeller be the same, which, we have seen, implies that $\mu = 1$.

The Italians, instead, look at the problem from a different point of view, and say: It is true that in order to compare the results as obtained from model experiments with the results obtained from full-sized propellers, the angle through which the blades of the two propellers are deflected should be the same, but in practice, we do not obtain such a desirable condition: first, because the models are sometimes made out of a single piece of wood, while the full-sized propellers are made out of several pieces glued together; second, even when the models are made out of several pieces glued together, same as the full-sized propellers, the number of pieces of wood making up the two propellers is not always the same, and the pieces are not cut geometrically similar. Such being the case, the model propeller is never exactly geometrically similar to the full-sized propeller, and it is of no use to impose on the experimenter some limiting conditions issuing from the assumption that the angle through which the two propellers are deflected is the same, when in practice this is not obtained.

Disregarding the deformation of the blade under the influence of the aerodynamic force, the Italians say: calling $\theta = \frac{T}{t}$ the ratio of the two times, if the acceleration due to the gravitation is considered, it will be the same for the two propellers when:

$$\frac{L}{T^2} = \frac{l}{t^2}$$

or

$$\frac{L}{T^2} : \frac{l}{t^2} = \frac{\lambda}{\theta^2} = 1$$

giving $\lambda = \theta^2$.

The ratio of the velocities will be:

$$\frac{V}{v} = \frac{L}{T} : \frac{l}{t} = \frac{L}{l} \times \frac{t}{T} = \lambda \frac{1}{\theta} = \frac{\lambda}{\sqrt{\lambda}} = \sqrt{\lambda}$$

giving:

$$v = \frac{V}{\sqrt{\lambda}} \quad . \quad . \quad . \quad . \quad (5)$$

instead of $v = V$, as adopted by the French.

The ratio of the angular velocities of the two propellers will be:

$$\frac{\Omega}{\omega} = \frac{N}{n} = \frac{1}{T} : \frac{1}{t} = \frac{1}{\theta} = \frac{1}{\sqrt{\lambda}}$$

giving:

$$n = N \sqrt{\lambda} \quad . \quad . \quad . \quad . \quad (6)$$

instead of $n = \lambda N$, as adopted by the French.

The ratio $\frac{V}{N D}$ can be expressed like this:

$$\frac{V}{N D} = \frac{v \sqrt{\lambda}}{\frac{n}{\sqrt{\lambda}} \lambda d} = \frac{v}{n d}$$

showing that both with the French and the Italian method the condition $\frac{V}{N D} = \frac{v}{n d}$ is satisfied.

The difference between the Italian method and the French method is this: The Italians recognise that the French method is the correct one, but do not follow it, because, in practice, they say, it is not easy to have a model propeller of exactly the same material, and strictly geometrically similar to the full-sized propeller and adapt the theory to the prevailing experimental conditions. The French, instead, recognising that the deflection of the propeller blades is of primary importance, affecting as it does, the angle of incidence, do not compromise with theory and try to adapt the experimental conditions (design of the balance and construction of model propellers) as much as possible to the theory enunciated before.

By using the value of $\frac{N}{n}$ as adopted by the Italians, formulae (4) become:

$$\left.\begin{aligned} \frac{F}{f} &= \frac{a\, N^2 D^4}{a\, n^2 d^4} = \left(\frac{1}{\sqrt{\lambda}}\right)^2 \lambda^4 = \lambda^3 \\ \frac{C}{c} &= \frac{\beta\, N^2 D^5}{\beta\, n^2 d^5} = \left(\frac{1}{\sqrt{\lambda}}\right)^2 \lambda^5 = \lambda^4 \\ \frac{P}{p} &= \frac{\beta\, N^3 D^5}{\beta\, n^3 d^5} = \left(\frac{1}{\sqrt{\lambda}}\right)^3 \lambda^5 = \lambda^5 \sqrt{\lambda} \end{aligned}\right\} \quad . \quad (7)$$

In our case at the St. Cyr Institute, taking the same numerical values of λ, N, P, and F as used before, if we had followed the Italian method for interpreting the relation between results derived from model propellers, and those to be anticipated from full-sized propellers, we should have designed our balance so as to give:

$$n \text{ (max.)} = N \sqrt{\lambda} = 1{,}500 \sqrt{3} = 2{,}600 \text{ r.p.m.}$$

$$p \text{ (max.)} = \frac{P}{\lambda^5 \sqrt{\lambda}} = \frac{5{\cdot}0}{3^5 \sqrt{3}} = 10{\cdot}6 \text{ h.p.}$$

$$f \text{ (max.)} = \frac{F}{\lambda^3} = \frac{450}{3^3} = 16{\cdot}6 \text{ kilog.}$$

These results are noticeably smaller than those we found before.

Dr. W. F. Durand, in his report No. 14, to the National Advisory Committee for Aeronautics, on Experimental Research on Air Propellers, gives the discussion of the law of kinematic similitude in its relation to propeller experiments, and, applying the theory of dimensional homogeneity, arrives at the conclusion that, in order to be able to deduce from model forms the exact characteristics of full-sized forms, the following conditions should be simultaneously fulfilled for the two propellers:

(1) same values of $\frac{V}{N D}$
(2) same values of $D V$
(3) same values of V
(4) same values of $\frac{E}{V^2 \Delta_1}$
(5) same values of $\frac{\Delta_1}{\Delta}$

where:

E = coefficient of elasticity of blades material.
Δ_1 = density of blades material.
Δ = density of medium,

the other symbols having the same meaning as before. Obviously, the only way in which these five conditions can be simultaneously fulfilled is by making D, N, V. R, and Δ_1, the same for the model propeller and the full-sized propeller.

In model experiments, being as we are interested in such cases as will permit the use of different values of D, a small value for the model and a larger value for the full-sized form, we must compromise and have the choice of simultaneously meeting conditions 1, 2, 5 or 1, 3, 4, 5. The omission of condition 2 is equivalent to neglecting the influence of the viscosity of the air, but, as Dr. Durand points out in his report, where the movement is as turbulent as that about an air propeller, this seems permissible without the danger of involving an error of sensible magnitude.

Dr. Durand suggests as a practical solution of the problem:

(1) equal values of $\frac{V}{N D}$
(2) equal values of V
(3) equal values of $D N$
(4) equal values of E and Δ_1

which agrees perfectly with the French method illustrated before, which was finally adopted by the French Technical section of Military Aviation for establishing the fundamental designing data of the new balance.

The general arrangement of the Crocco balance was preserved in the new design, and a desirable feature of the Durand balance was also incorporated.

Crocco Balance.—In the Crocco balance, which is schematically represented in Fig. 1, a 3-h.p. variable speed D.C. motor, maximum speed 1,500 r.p.m., is supported on a framework structure right above the experimental chamber of the wind tunnel. The rotary motion of the motor axis is transmitted through two bevel gears to a vertical shaft A, the r.p.m. of A being double the number of r.p.m. of the motor axis. At the opposite end, shaft A is geared to two horizontal shafts C and D, and through them to a second vertical shaft placed on the same axis of shaft A—four equal gears link together the four shafts.

A third vertical shaft E placed in the same axis as the other two vertical shafts is connected to them through a cardan O, which allows a free oscillation of E and the frame structure J around the horizontal axis XY perpendicular to the axis of the tunnel and coinciding with the axis of oscillation of the cardan. At the free end, shaft E is geared to the propeller shaft F, the number of r.p.m. of the propeller being double the number of r.p.m. of the vertical shaft and four times the number of r.p.m. of the motor. The swinging arm E, and the gears G are all enclosed in a casing of a suitable shape such as to reduce to a minimum the turbulent motion of the air behind the propeller.

The resisting torque of the propeller reacts on the four gears linking together the vertical shafts with the two horizontal shafts C and D, which will have tendency to rotate in an horizontal plane around the vertical axis, and are prevented from doing so by adding weights at L. Opposite the free end of shaft D, by using a special clock-work arrangement, the number of r.p.m. of shaft A is recorded on a revolving drum. Knowing the weights added at L and the length of lever arm C, it is easy to calculate the resisting torque, which will be the resisting torque of the propeller plus the frictional resistance of the gears in the transmission.

The Italians make the necessary correction of the torque so measured by using a set of calibrating curves, giving the efficiency of the transmission in terms of the magnitude of the weights added at L and of the r.p.m. of shaft A. For small values of the weights added at L, the efficiency is very low. When the weight at L is in the order of magnitude of about 4 kg., the efficiency of the transmission is about the same at all speeds, and is equal to ·92.

The fact that the torque measured at L included the resisting torque of the transmission gears, was judged to be a disturbing factor, which it was desirable to eliminate in the St. Cyr balance, as it was likely to influence, in some cases, to a noticeable extent, the measure of the torque. In fact, if we were concerned with the measurement of large propeller torques only, the resisting torque of the transmission would probably be a small percentage of the total, and, by neglecting it, the error made would not be a large one. But, in the case of small propeller torques, the resisting torque of the transmission may be large enough to seriously affect the experimental results.

The method used by the Italians of multiplying the torque measured at L by a numerical factor called efficiency of the transmission (obtained by using in place of the propeller an electric brake of the Pasqualini type, made by Galileo Galilei, Florence, Italy), only corrects the error to a certain extent because the resistance of the transmission depends on the lubrication of the gears and on the atmospheric temperature as affecting the viscosity of the lubricant, &c., which are not accounted for in the calibration curves.

The propeller thrust has the tendency to give rise to an oscillation of E, and the structure J rigidly connected to it around the horizontal axis XY, and it is prevented from doing so by the addition of weights at H.

Knowing the distance of H and the distance of the propeller shaft from the axis of rotation XY: (1 m. and 2 m. respectively) the actual value of the propeller thrust will be equal to one-half the weights added at H. This does not include, of course, the air resistance of the casing containing the shaft E and the gears transmitting the rotation to the propeller, which must be added to the force measured at H before dividing by 2. The resistance of the casing at different values of the wind velocity in the tunnel is obtained from a calibrating curve made for that purpose.

Four dash pots, M, two at each end of the oscillating axis of the balance, reduce the amplitude of the oscillations, and make it more easy to weigh the thrust at H. Four counterweights K adjustable along four vertical rods, are used for bringing the centre of gravity of the oscillating system in proximity to the axis of rotation XY, thus increasing the sensitiveness of the balance.

Two men are needed to operate the balance: one

for measuring the torque and the other for measuring the thrust. A third man regulates the speed in the wind tunnel by changing as required the speed around the drum, the number of r.p.m. of shaft A at the moment when the balance was in equilibrium is found. The number of r.p.m. measured on drum N, the weights measured at H and at L and the wind speed in the tunnel at the instant when these measurements were made, give all the elements for calculating the thrust and the torque of the model propeller under test.

All that is needed for working accurately and rapidly is to have three trained men, preferably always the same men, working together intelligently. The three sections of the vertical shaft are made out of steel rods, the oscillating frame J is made out of steel tubes. Roller bearings are used at the motor shaft extension, and at the axis of rotation XY. The maximum diameter of propellers used by the Italians in the experimental chamber of the tunnel, 2 m. in diameter, is 50 cm.

Fig.1. COL. CROCCO'S BALANCE FOR TESTING PROPELLERS.

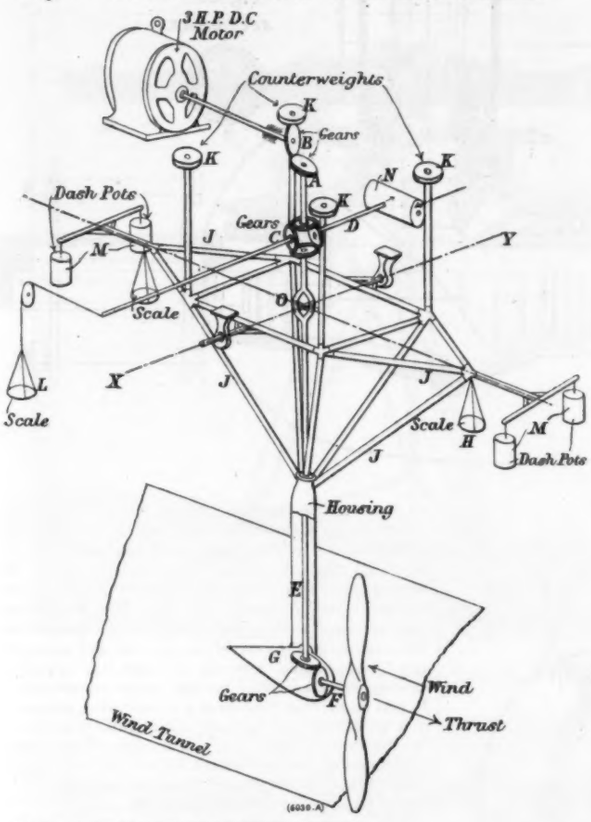


Fig.3. ST CYR AERODYNAMIC BALANCE FOR TESTING PROPELLERS

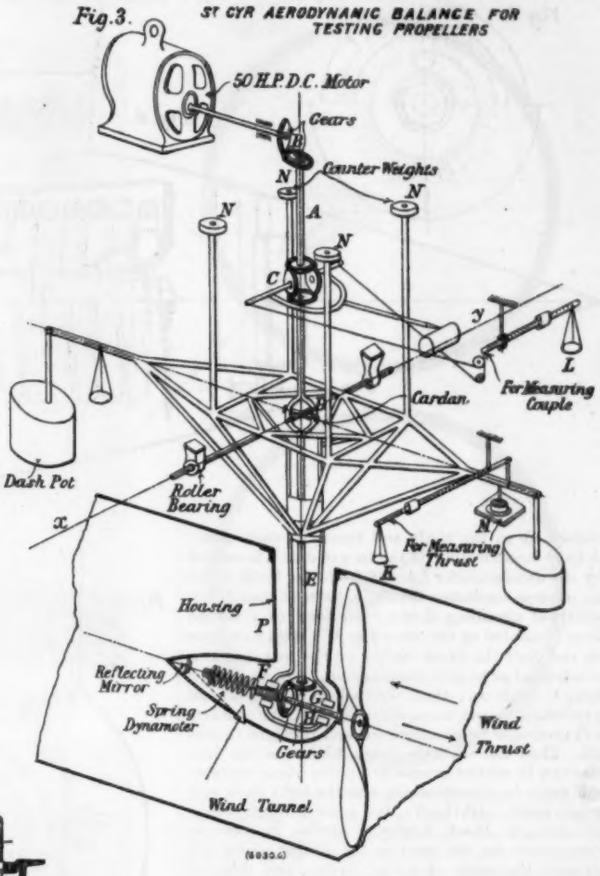


Fig.2. Dr DURAND'S BALANCE FOR TESTING PROPELLERS.

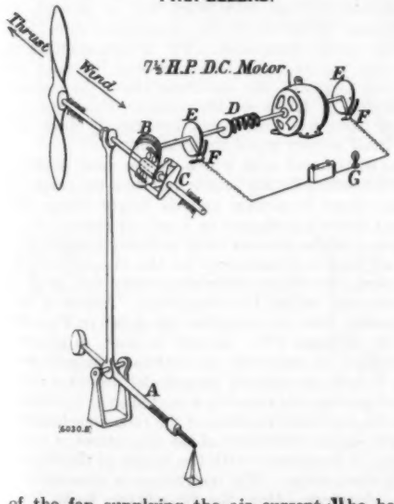


Fig.4.

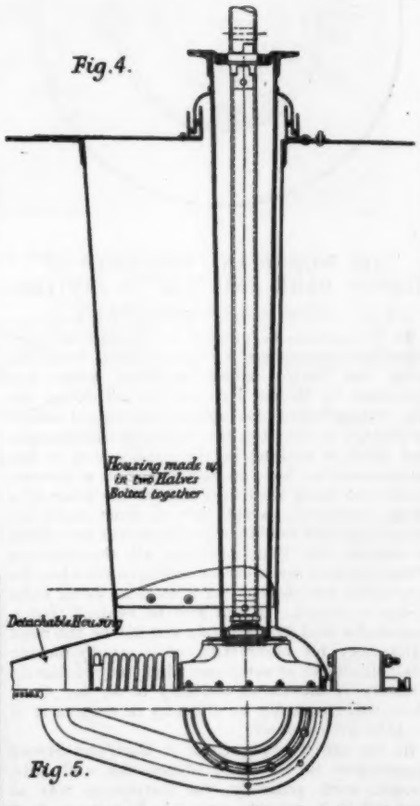


Fig.5.

Durand Balances.—The Durand balance, which is schematically represented in Fig. 2, consists of a propeller shaft 1¼ in. in diameter which runs in oil-ring bronze bearings. This shaft is driven without longitudinal constraint through a yoke C at the rear end, having hardened steel flat longitudinal surfaces which engage with six small steel rollers on a companion yoke carried by a bevel gear B. The bevel gear runs on ball bearings outside the hub, which is bored to provide freedom from contact with the propeller shaft. The driving motor, a 7.5 h.p. D.C. motor, drives the propeller shaft through bevel gearing and the yokes mentioned.

In this manner the propeller shaft is subject to simple torque only, so far as the motor drive is concerned, and it is entirely free to move longitudinally as may be determined by other forces in play. These other forces are the pull (or thrust) due to the propeller shaft itself, and to some form of weighing or measuring device A calculated to control and balance such pull (or thrust).

A torque dynamometer D is inserted between the motor shaft extension and the transmission gear B. The torque on the motor shaft is measured by the torsion of the dynamometer spring D. To measure this torsion, two fibre discs E are fitted to the shaft, and one on each side of the spring. These discs carry a narrow metal strip on the edge to serve as an electric contact. The contacts are electrically

of the fan supplying the air current; he has in front of him a Kreil pneumometer on which he can read directly the velocity of the air in the experimental chamber of the tunnel. Each time that he reads the pneumometer, the air velocity at which the experiment is to be performed, he presses a button, a bell rings, and the two men operating the balance, try to equilibrate at the same time the oscillating structure J and to bring the swinging arm D to the zero position marked off on the drum N. When, after several trials, this condition is obtained, at the desired wind velocity in the tunnel, the drum N is set rotating. After the drum has made a complete rotation, the rotating mechanism is stopped again, and, on the recording card wrapped

THE ST. CYR AERODYNAMIC BALANCE FOR TESTING MODEL PROPELLERS.

Fig. 7.

Fig. 6.

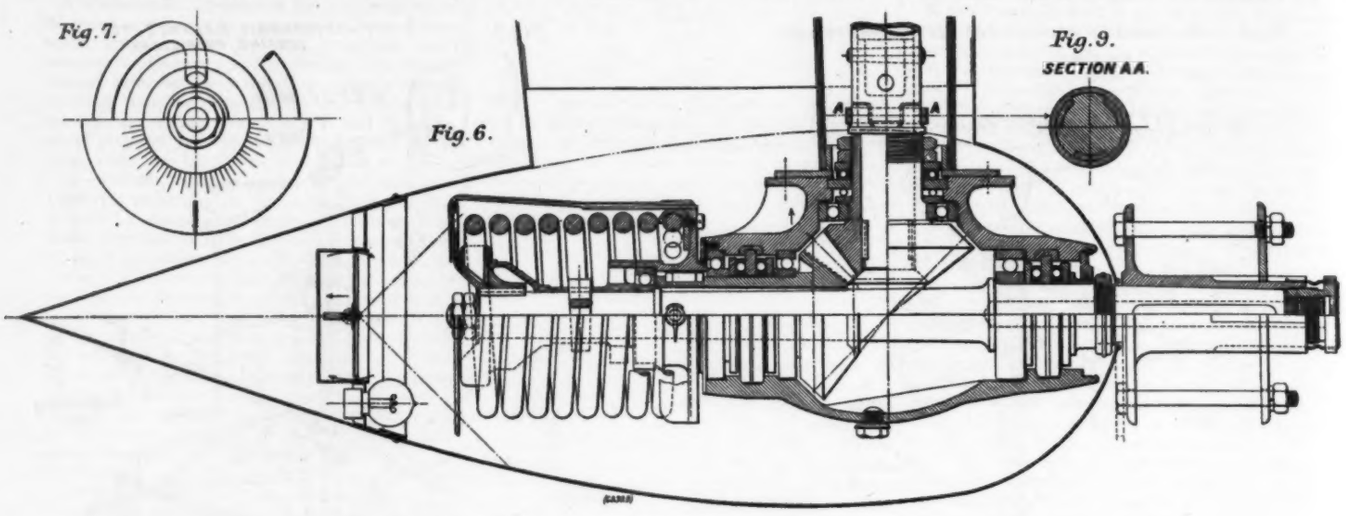


Fig. 9.
SECTION AA.

connected to the shaft and hence to each other. A fixed brush resting on the face of disc E is carried by the dynamometer frame; from this brush is led an electric conductor first to a battery then to an electrical signalling device, and then to a second brush mounted on the other disc E. With no torque on the shaft the brush carrier on the rear disc E is so adjusted as to give simultaneous contacts and the lamp G lights up; then, with a load thrown on and a resultant torque, the spring will twist, the contacts will no longer be simultaneous and the light G goes off. Then the movable brush holder on the rear disc can be moved around to a point where contacts will again be simultaneous, and the light on G will go on again. Obviously, the angle through which the movable brush holder is carried in order to compensate for the twist in the driving spring will measure the angle of spring torsion, and this, by suitable calibration, is readily translated into torque measurement.

The St. Cyr Balance.—As we said before, the general arrangement of the new balance is similar to the Crocco balance. Fig. 3 is a schematic view of the St. Cyr balance. A 50-h.p. D.C. variable speed motor 200/1,500 r.p.m., produces through the bevel gears B, C, G, the vertical shafts A, E, and the cardan D, a maximum speed of rotation of the propeller shaft H of 4,500 r.p.m.

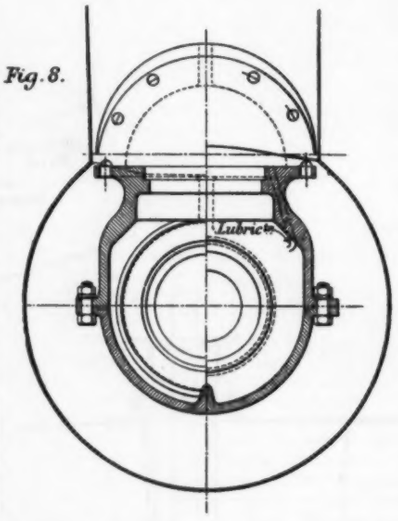
On the propeller shaft, a torque dynamometer similar to that used by Dr. Durand on his balance, can measure directly the propeller torque which is also simultaneously measured at L, following the same general arrangement already described in connection with the Crocco balance.

Figs. 6 to 9 are detail views of the dynamometer, the transmission gears, and the propeller hub, and show how the motor torque is transmitted through the bevel gears G to an hollow shaft, which transmits the torque to the propeller shaft through a spring dynamometer. The resisting torque of the propeller is determined by the angle of torsion of the spring which is measured by a stroboscopic arrangement.

The torque transmitting mechanism and the oscillating arm E are enclosed in a casing fixed to the tunnel. Figs. 4 and 5 show the details of the air-tight passage of the oscillating arm E through the wall of the tunnel. A set of calibrated springs will be used for the different speeds at which propellers will be tested.

The propeller thrust will be measured at K in the same way as it is measured on the Crocco balance, and in addition it is simultaneously measured on an hydraulic manometer M. The four counterweights N will be used for bringing the centre of gravity of the oscillating system in proximity to the axis of oscillation xy. Solid steel, shafts, steel tubes and roller bearings will be used in the construction of the balance.

Fig. 8.



THE WORKS AND PRODUCTS OF MESSRS. BARR AND STROUD, LIMITED.

(*Continued from page* 672.)

In this article we propose to describe the very beautiful instrument for determining both the range and height of an aeroplane which was developed by Messrs. Barr and Stroud during the war. Rangefinding of aeroplanes does not, of course, necessarily involve the use of special instruments, and there is nothing in the construction of the rangefinders we have already described to prevent them from being used to determine the range of a flying aeroplane, except that in some cases the mountings used would not give sufficient movement in altitude, and that, in almost all, the situation of the eyepieces would become inconvenient when the instrument was directed on a machine flying more or less overhead. It will also be evident that a rangefinder held in the hands will not be the most satisfactory for observation of a rapidly-moving small object like an aeroplane, which may change its direction of movement suddenly or at any time. There will frequently be difficulty in keeping it in the field of view at all.

In the earlier applications of Barr and Stroud rangefinders to aeroplane observation and anti-aircraft work generally, the instrument was so arranged on its mounting that the base swung in a vertical plane. The eyepiece was situated in the line of the trunnion on which the instrument swung, so that it was possible for the operator to make observations with comfort and facility on objects at all altitudes. When observing an aeroplane directly overhead the base of the instrument would lie horizontally, and when observing an object on the horizon it would stand vertically. The mountings were arranged with a pair of hand wheels controlling the instrument respectively in altitude and azimuth, and giving rapid motions so that the quickly-moving machine could be kept under observation. It will be evident that such a rangefinder, swinging in a vertical plane, gives, by the angular position of the instrument itself, a direct reading of the angle subtended at the instrument by the vertical height of the observed aeroplane above the ground. This indirectly, and in conjunction with the observed range, gives a measure of that vertical height. The simplest form of range and height finder is an instrument of this class fitted with a pointer, or pendulum, attached to the rangefinder tube and moving over a fixed scale. By an arrangement of this sort the angle of elevation may be read off and the height of the aeroplane above the ground calculated in terms of the range. This type of arrangement has been used, but clearly does not lend itself to very rapid observation.

The instrument with which we are more particularly concerned in this article indicates the range of an aeroplane or airship and its height above the ground directly in figures on a pair of scales. It is used in a similar manner to an ordinary rangefinder, and all that it is necessary for the observer to do is to keep the object under observation in the field of view, and adjust for coincidence. Views of the instrument from the two sides are shown in Figs. 63 and 64, on page 777. As will be seen, in general appearance it resembles an ordinary rangefinder. It is, in fact, an ordinary rangefinder provided with special gearing and suitably mounted so as to obtain from the combined motions of the range mechanism and the angular elevation of the instrument, a scale moving in accordance with the height of the object under observation. The instrument is operated by three observers. One, the rangetaker, looks into the eyepiece at the centre of the instrument and operates the working head and the elevating hand wheel. His duty is to obtain and keep coincidence of the target images. The second operator stands beside the rangetaker and looks into a finder eyepiece. He operates the azimuth-training hand-wheel and his duty is to keep the observed object in the field of view in azimuth. The third operator acts as a scale reader, and stands on the opposite side of the instrument. He reads the height and, when desired, reads also the range and angle of elevation on the various scales when the rangetaker has obtained coincidence of the target images.

The rangefinder has a base length of 2 m. and is

HEIGHT- AND RANGE-FINDER FOR THE OBSERVATION OF AIR-CRAFT.

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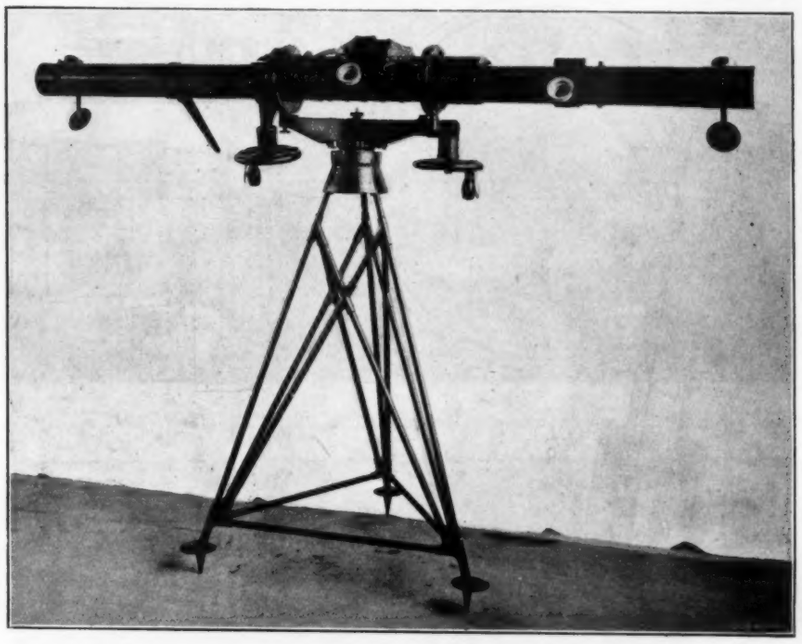


FIG. 63. RANGETAKER'S SIDE OF INSTRUMENT.

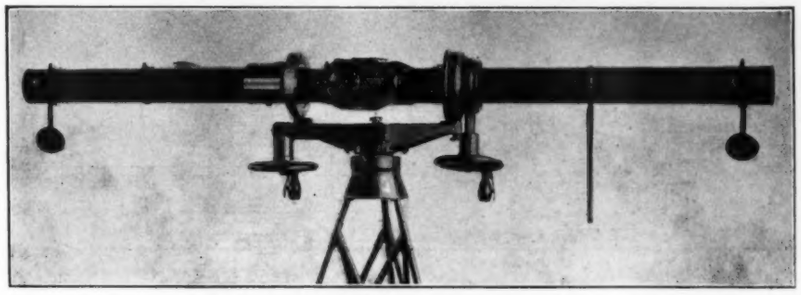


FIG. 64. SCALE-READER'S SIDE OF INSTRUMENT.

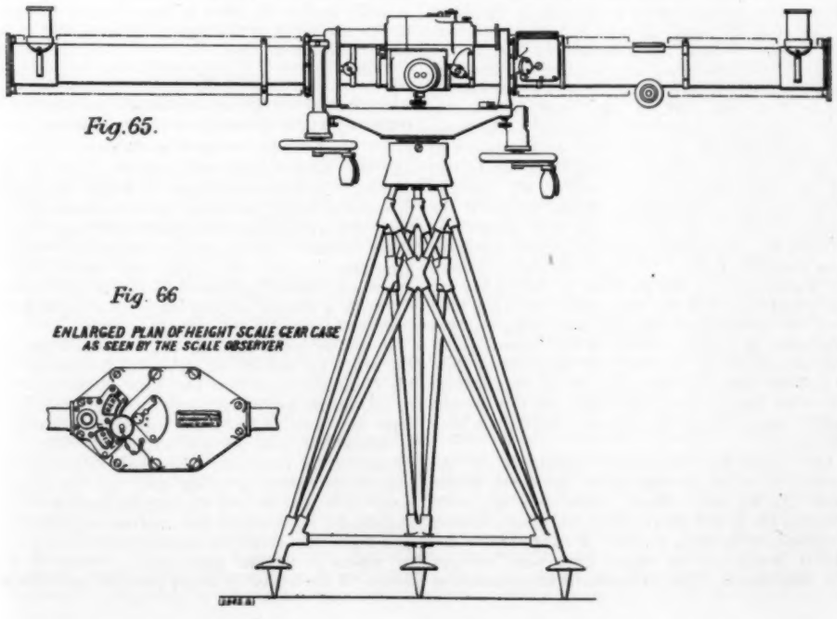


Fig. 65.

Fig. 66

ENLARGED PLAN OF HEIGHT SCALE GEAR CASE AS SEEN BY THE SCALE OBSERVER

Fig. 67.

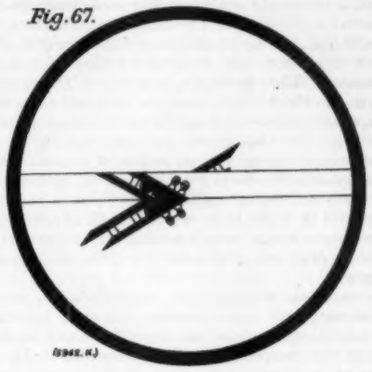
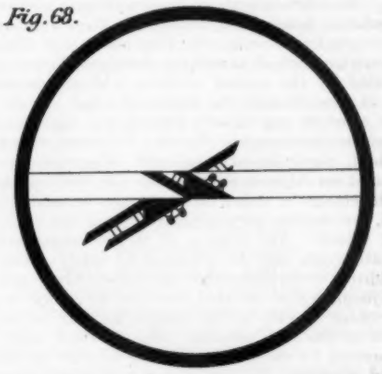


Fig. 68.



carried on a rigid tripod stand, as shown in Fig. 63. This figure, and also Fig. 65, show the rangetaker's side of the instrument. The eyepiece is situated at the centre and can be seen in Fig. 63, in which it appears as a white cup-shaped object. This is the rubber lip which is added to exclude external light and to make the instrument more comfortable in use. The eyepiece is placed at right angles to the plane of triangulation so that when the instrument is directed towards an object on the horizon the rangetaker looks vertically downward, and when it is directed towards the zenith, the rangetaker looks in horizontally. There are two lens combinations provided on a rotatable cap which give magnifications of 15 and 25 diameters respectively. The eyepiece is provided with light filters for use under varying atmospheric conditions. The eyepiece is of the single type and is not arranged so that one eye of the observer views the range field and the other the range scale in the manner we have described in connection with previous instruments. There is, however, a window above and to the left of the eyepiece through which the internal scale attached to the deflecting prism may be read when required. This scale is provided for use when adjusting the instrument and also—for reasons which we will deal with later—for use when taking ranges above 12,500 yards. This internal scale carries an infinity mark beyond the highest range figures. For ordinary use the external scale on the opposite side of the instrument is read, by the third observer, as we have already explained. This scale is engraved around the face of a circular ring and is viewed through a window in the gear-case. A second window displays the height scale. The gear case and windows can be seen in Fig. 64, but are perhaps better shown in the small separate plan view of the gear-case given in Fig. 66.

The rangefinder deflecting prism gear and the height and range scale gearings are both actuated by the movement of a working head which is situated on the window side of the outer tube and immediately to the right of the right bearing ring. This working head is operated by the observer when obtaining coincidence in the field of view exactly

as we have previously described in connection with other instruments. The rangefinder is carried in the mounting forks in two eccentric bearing rings, the object of the eccentricity being to balance the weight of the height-scale gear-box as the instrument is rotated in elevation. The total rotation arranged for is 93 deg., giving an elevation adjustment of the line of sight from the vertical position to 3 deg. depression. The elevating gear is of the worm and worm-wheel type, and is actuated by the hand wheel situated below the left bearing of the mounting. The hand wheel is provided with a two-speed clutch operated by means of a small lever associated with the hand grip. An elevating handle, which can be seen toward the left-hand end in Fig. 63 and the right-hand end in Fig. 64, is provided for making a quick, rough setting. Details of the elevating gear are given in Figs. 69 to 71, on this page.

The azimuth-training gear is also of the worm and worm-wheel type, and is actuated by the hand wheel situated on the mounting head to the right of the rangefinder. It is provided with a two-speed clutch, in a similar manner to the elevating gear. An azimuth scale and index are provided on the rotating head of the mounting. The scale may be oriented relatively to the mounting. This azimuth hand wheel, as we have already explained, is operated by the second observer who sights the field of view through the finder telescope, the eyepiece of which can be seen towards the right-hand end of the instrument in Fig. 63. The worm wheels for both elevation and azimuth adjustment are mounted on friction slip-bearings, so that quick, rough settings in either direction may be made by hand, fine setting being obtained by the use of the hand wheels. The friction of the elevating and azimuth gears may be adjusted by small screws. In addition to the finder telescope already mentioned, four rough sights are also provided to enable the instrument quickly to be brought to bear on the target in the first instance. One of these sights is provided for the rangetaker and another for the second observer, the remaining two being fixed one near each of the end windows.

The general features of the rangefinder part of the instrument do not in the main differ from those of the rangefinders we have already described, and it is not necessary for us to enumerate them. The instrument is, for instance, fitted with astigmatiser gear, and arrangements for making the various necessary adjustments. A feature in which the instrument does, however, differ from those we have previously dealt with is in the provision of two inner frames separately supported from the outer tube. One of these inner frames carries the fixed optical parts, such as the objectives and central reflecting prisms, and the other carries the movable optical parts comprising the deflecting prism, the halving glass and the rotating prism for the adjustment of coincidence. This arrangement has been introduced with the idea of avoiding errors due to alteration in the balance of the frame as the deflecting prism is moved longitudinally.

Another point of difference between this rangefinder and others dealt with in our earlier articles is in the appearance of the field of view. This is shown in Figs. 67 and 68, page 777, which illustrate the field when the instrument is directed on an aeroplane. As will be seen the main image appears upright, but across the field of view there is a strip in which the image appears inverted, but not reversed right for left. This strip field arrangement is not peculiar to the instrument we are now dealing with, but is used in other rangefinders. We have not had occasion, however, previously to mention it. It will be understood from our figures that all parts of the image seen in the two main portions of the field are formed by rays of light which enter the instrument by one window, and all parts seen in the centre strip by rays which enter by the other window. The left-hand window and pentagonal direct the rays which form the main image into the eyepiece prism system, and the right-hand window and pentagonal similarly direct the image forming the strip field. The division of the field of view into its two parts is carried out in the central prism system in a manner generally similar to that we have described in an earlier article for the ordinary split-field system. The advantage of the strip field method for use when observing an aeroplane is that it is somewhat easier to keep the object in the field of view. It will be clear that with any system of field the inversion of part of the image is desirable since it is easier to ensure that coincidence is properly obtained on a small moving object if the one part, or edge, and its inversion can be lined up as shown, for instance, on the lower line in Fig. 67. If, however, the whole upper half of the field were inverted, although one would still get the lining-up as shown in Fig. 67, the disadvantage of the arrangement would be that if the image in the lower half of the field passed the dividing line, the aeroplane would entirely disappear from the field of view. In effect, instead of having the whole field for the machine to manœuvre in, one would have half the field only. The strip field gives the advantage of the inverted image and yet eliminates this latter defect of the inverted half-field arrangement. It will be clear from Figs. 67 and 68 that coincidence has to be obtained on the lower line of the strip field. In Fig. 67 the partial images are in coincidence. In Fig. 68 they are not.

The remaining feature of importance in the instrument is the gearing which drives the height scale. As we have already made clear this scale indicates the height above the ground of an observed aeroplane, or airship, directly in figures when the partial images of the object have been brought into coincidence. The indication is independent of the angle of elevation of the object as seen from the rangefinder. What the height-scale gearing actually does is to solve a trigonometric formula. If r be the range of the object observed and α its angle of elevation, then:

$$\text{(i) } r \sin \alpha = h,$$

where h is the height above the ground which it is required to determine. From (i) we obtain:

$$\text{(ii) } \log r + \log \sin \alpha = \log h,$$

and this is the equation which is solved by the gearing. A differential gear is fitted, the upper member of which is rotated in accordance with a logarithmic sine scale of angles of elevation, and the lower member is rotated in accordance with a logarithmic scale of ranges, the jockey wheel accordingly revolving around the axis of the differential with a motion corresponding to a logarithmic scale of heights.

It will be noted that the angle of elevation and the range are known, or rather are determined by the instrument, so that the duty of the gears is to convert the angle and range scales to logarithmic form and then to add them together by means of a differential gear as just explained. The conversion of the reciprocal range scale motion of the rangefinder deflecting prism gear into logarithmic range scale motion and the angular motion of the rangefinder in elevation into motion corresponding to a logarithmic scale of sines is done in each case by means of toothed spiral gears. Owing to the nature of the scales, it is not possible to construct

DETAILS OF HEIGHT- AND RANGE-FINDER.

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Fig. 69.

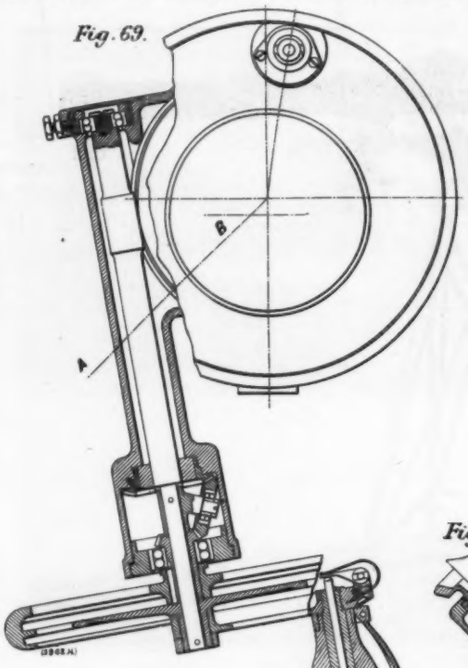


Fig. 70.

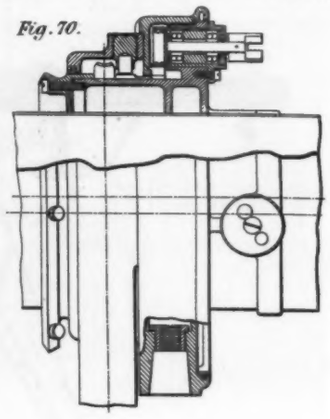


Fig. 71. FALSE SECTION ON A.B.

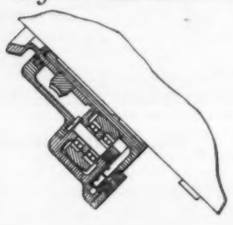
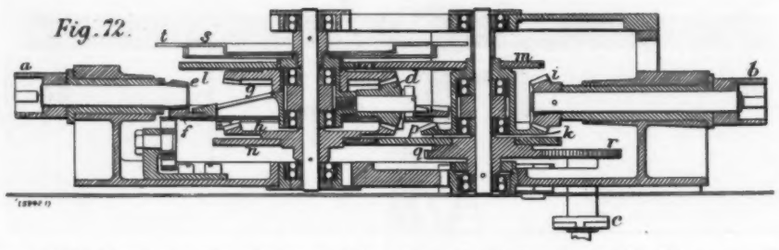


Fig. 72.



DETAILS OF HEIGHT- AND RANGE-FINDER.

CONSTRUCTED BY MESSRS. BARR & STROUD, LTD., ENGINEERS, ANNIESLAND, GLASGOW.

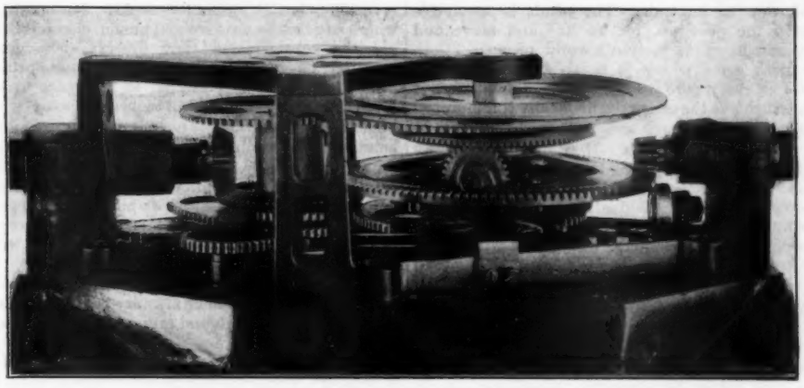


FIG. 73. VIEW OF GEARING: RANGETAKER'S SIDE.

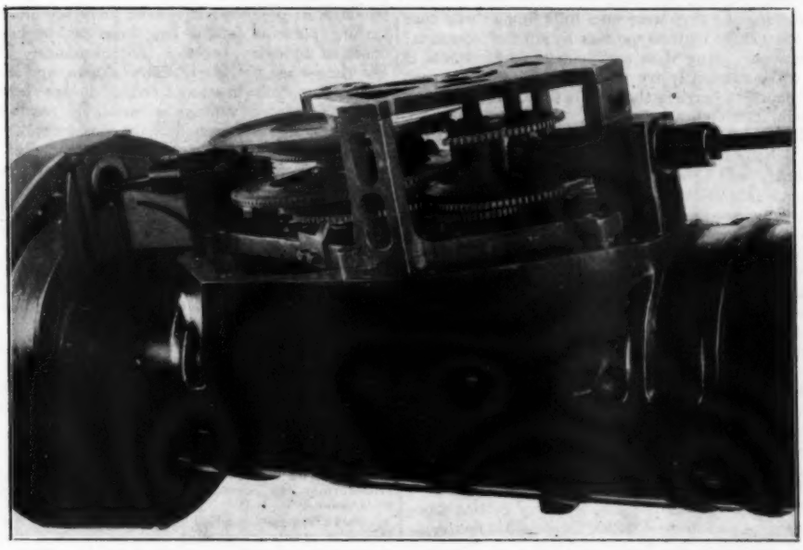


FIG. 74. VIEW OF GEARING SHOWING ELEVATING MECHANISM DRIVE.

gears which will give correct readings outside certain limits. The height scale is correct only for angles of altitude between 10 deg. and 70 deg., and an instruction plate to this effect is fixed on the rangefinder, in close association with the angle of elevation scale. For a similar reason the external range scale graduations are carried only up to 12,500 yards, ranges above this limit up to infinity being read from the internal scale attached to the deflecting prism and seen through the window in the outer tube near the eyepiece. We have previously referred to the necessity for using this internal scale for ranges above 12,500 yards.

A cross-section of the gear is given in Fig. 72, on page 778, while two perspective views are given in Figs. 73 and 74, on this page. The gearing is connected to the rangefinder through three couplings *a*, *b* and *c*. Coupling *a* connects it to the working head, coupling *b* to the elevation gear and coupling *c* to the deflecting prism gear. It will be seen from Fig. 72 that the jockey wheel *d* of the differential is driven from the working head coupling through the intermediation of a bevel pinion and wheel *e* and *f*, the range scale and the deflecting prism gear thus being driven indirectly through the differential gearing. The upper and lower members of the differential are respectively lettered *g* and *h* in the figure. The upper member *g* is controlled by the movement of the instrument in elevation from coupling *b* through the bevel gearing *i* and *k* and the toothed spiral gears *l* and *m*. These latter gears convert the angular motion into motion in accordance with log sin *a*. The lower member of the differential, *h*, is connected through spiral gears *n* and *p*, and the spur gears *q* and *r* to the rangefinder deflecting prism gear coupling *c*. The spiral gears *n* and *p* are so designed and calculated that while the gear *p* rotates in accordance with the reciprocal range scale of the rangefinder, the gear *n* rotates in accordance with a logarithmic scale of ranges. The range scale *s* is connected to the lower member *h* of the differential, and the height scale *t* is connected to the bevel wheel *f* carrying the jockey *d*.

The advantage of arranging the working head to operate the jockey wheel is that in the frequent case of aircraft flying at a constant height the images in the field of view, when once set, can be kept in coincidence by simply elevating the instrument so as to keep the target in the centre of the field, without any rotation of the working head. The movement of the instrument in elevation automatically controls the position of the deflecting prism, from bevel gearing *i* and *k*, and so through the upper and lower spiral gears and the differential to spur gearing *q* and *r*; the height scale remaining unaltered so long as the working head is not rotated. When the target rises or falls, the images will move out of coincidence and must be brought back into alignment by rotating the working head, thus altering the reading of the height scale by the appropriate amount. The working head and elevating gear may, of course, be worked at one time, in which case the combined effect of the spiral gears and the differential is that the two scales always read correctly as long as coincidence is maintained.

In order to prevent damage to the gearing by forcing it beyond the stops, the bevel wheel *f* is mounted on a friction slip bearing which allows it to slip when the gear is against the stop at either end. Our figures do not show the form of the spiral gears very well, but they can be to some extent seen in Figs. 73 and 74. The latter figure clearly shows the connecting of coupling *b* to the elevating gear of the rangefinder. A detail of the drive is shown in Fig. 70. Incidentally we may say that the spiral gears are of such unusual form that we believe one foreign patent office refused to deal with them on the score that they could not be made. The forwarding of an actual example of the gear was necessary to convince these authorities that the gear was a practical one. We may say that no attempt is made to use a copy-plate method in the manufacture of these gears. They are cut in small batches on a horizontal milling machine, a special dividing plate having been constructed for the purpose and each tooth being set for and cut independently. The operator works from a table which gives instructions for each tooth.

In conclusion it should be pointed out that this instrument is intended for use only on land, and that provision is made for accurately levelling the mounting head. For use on board ship a different instrument, with the height-scale gear controlled by a pendulum, is made.

(To be continued.)

THE PERSONAL EQUATION.

To review the subject of personality and temperament in their reaction between man and man is a task which has employed every creative literary artist since the dawn of such art.

An equation is a mathematical expression having for its object the solution of unknown quantity by a series of outflanking movements. Correct statement and logical manipulation serves to establish a result which can be followed step by step to each of which the mind assents. Elucidation is the end desired; the entire process is capable of repetition, and the result certain, given the same or similar initial premises. The human equation is the direct contrary of its mathematical similar, in that while the process of manipulation is endless the result is never known, for in any event it must be an approximation, in too many instances a disappointment. It is clearly impossible to liquidate the nebulous unless in the first instance you change its state, it is not possible to liquidate or crystallise a human result unless you first divest the human of its humanity. Like causes are, however, to be presumed to have like effects, and similar antecedents give similar consequents. It is the tracing of cause and antecedent to their ultimate and inevitable effect and consequent which is the basic essential of verbal art. Unless the story hangs together upon a theme its narrative interest is broken, it may be a series of episodes uncoordinated, but unless a deliberate theme can be discovered it is simply words without the touch of mastery.

In human relationships generally so many qualities are intermixed and mingled that the equation of these to any given result has always perennial interest. The first essential in any capacity is that the individual must assess at a reasonable standard of accuracy the men with whom he has to deal. The second essential is to discover if possible their weaknesses and limitations, and to separate these as far as possible from their strong points.

Every man has weak points, just as every man has some sterling qualification, it is necessary by some process or other to get these duly in perspective. In fact, in many instances weakness is in proportion to competency, otherwise the problem of the clever, accompanied by some characteristic which fails him in a human sense, would be inexplicable. Character it need scarcely be said is at least as important as ability, and is less easy to discover.

In actual practice every subordinate tries to assess

his superior, and the superior is wise in proportion as his valuation of each man under him is accurate.

Where a superior has a notorious weakness—it may be vanity, vainglory, prejudice, pride, or a belief in his own infallibility—the joint in his armour is sure to be exploited by the unscrupulous. The subordinate desiring advancement can curry favour by playing up to the patent facts. On the other hand many an acute mind has obtained increased effort and maintained his position by playing to the gallery when this seemed expedient.

Not that all such wirepulling need be from a base motive, it may simply be done to make relations comfortable, some people call it tact, others diplomacy; at all events the line of individual approach should be without offence. To crave a favour as a right is surely unprofitable, while to refuse a request in a brutal and hectoring manner serves no good future end. The advice so freely tendered about hitching your wagon to a star is gratuitous unless means are available to effect the tractive force. In other words, it is useless to clamour for advancement if there is no opportunity for promotion, to do so simply means raising possible hostility.

To sit quiescent waiting with folded hands is equally unprofitable. A plan of campaign must be made and adhered to, qualifying in so indispensable a manner that when the opportunity comes it is impossible to overlook the fact that you are the only choice. Life is doubtless full of disappointments, and the call never comes exactly as you expect it, but real hard work, intelligence and due effort must meet at length with some reward. The majority let circumstances drift by; viewing closed doors they become disheartened, give up the struggle and settle as mediocrities in their location.

Determination and will-power are the result of the reaction of qualities indispensible to good work; coupled with real intelligence and training, most initial handicaps may be lessened, if not overcome. The preparation may be lengthy, the result long delayed, but persistent endeavour is the right spirit, for even if nothing results the individual is the greater and his competency more sure. In the evolution of character a purpose must be present, limitation must be realised that any drawback may be lessened; introspection is perhaps a bad habit, but a personal balance sheet is worth construction once in a while, and to underpin weak places is a commonsense counsel.

Concealed turnings and blind endings are useless to the traveller who must beware of both; they are disappointing and may be tragic. The unexpected rival and the forfeiture of main purpose are the besetting dangers. You may side track losing time, or end in blank negation of first high endeavours. In either case the main issue is not served.

The one great thing is to have clear purpose, with an understanding as to how this may best be served. Having laid plans taking many years to mature, it is useless upbraiding destiny because realisation is belated; time is at once an asset and a drawback, it gives balance and is also apt to slow down purpose.

Few men fail from incompetency, yet the fit survive; it is the extra few per cent. over others which gains the point. Many fail to realise that cultivation of personal qualities is at least as important as the acquirement of knowledge, good manners and speech serve a very real end. Tact and discrimination may be natural gifts, but no one is so destitute that these cannot be cultivated. These impersonal or rather intangible assets are neglected by many highly qualified men. When it is realised that sincerity of purpose and honesty of conviction, with a real desire to be helpful, are the cardinal axioms which make real character apparent—the failings of prejudice, envy and personal egoism being continually repressed—the road should be clear to raise the individual in this scale of assessment.

The human equation eternally defies exact solution, the variety of individual types is too great, and their permutation too various for any easy diagnosis; yet it is impossible to avoid the conclusion that it is perhaps more important than anything else. One individual who refuses to sink his prejudice and remains an unsoluble unit in the common weal, who is intolerable, though clever, finds himself penalised, and very rightly, on this ground alone. For no man lives to himself, he must get into contact with others and make the best of his environment; refusal to do this brings speedy retribution in its train. The result is inevitable granted the premises, for we live and move and have our being as men in a world of men. Contact with some people is nearly impossible, they bristle at every pore; such a personality is always set apart to live the cloistered life in any community; he sets himself apart, and may not complain of the result he achieves. Here brilliance may scintillate, but it is more solid and everyday qualities which count towards any end. An impossible person is a rejected individual, he cannot be digested by the mass. Hence the tragedies of genius so termed, the greater minds while preserving their gifts alive are not prone to insist upon these, they subordinate them to living issues.

Shakespeare, for instance, contrived to elude the critics of his day, he left no personal legacy, but he left the result of his art for a perennial joy to mankind. Lesser men have achieved notoriety, some live solely by arrogant assumption, some, like Johnson, by reason of their difference to the men who surrounded them. It is not that the great are superhuman, to claim this is to destroy their achievement; they were men fully human who rose to the height of their powers by dint of continual endeavour. Any man can achieve to his limits if he will consistently try to broaden these, once past the common barriers the field is illimitable, and the possibilities endless.

The human spirit infects industry no less than art, labour is a conglomerate of individuals not an inchoate and heterogeneous mass. The sooner the human side of labour is fully recognised the sooner will be ushered in the era of industrial peace. It is the human touch which is becoming realised in industry to-day; any system whose gearing is human must consider the individual cog, for organisation is in one sense more the substitution at due intervals of new teeth and the patching of weak places rather than a question of rule and method. It was previously left for the onlooker to appreciate the facts and call for mercy toward the discarded and worn-out human tools in the industrial world.

At length it is being realised that the human equation enters into production as much as into salesmanship, where personality has always had value.

Commercial transactions are getting more methodised while production is to-day getting more humanised and science, whose handmaid is commonsense, approves the changes made. It is the inert put to use and set in motion by intelligence—using labour, method, mechanism—serving the ends of utility, economy, convenience—which go to make up the complex machine of modern industry.

The greatest of these is human, the most intractible and fallible is human; conceived in a human brain, shaped by intelligence, wrought out by muscle, guided and controlled by hand and mind—industry cannot set aside the human factor or leave it out of consideration. It is the man who counts in the last analysis, whatever the wonder or perfection of his implements or the precision of his instruments. Nothing runs itself, and dependence must be placed time and again upon human units outside and beyond exact control. In the human equation human symbols interact, the resultant is human as well as all the terms, integrate and the variables are still human, neither system or organisation can discount its influence. Personal example, individual driving-force were never at a greater premium than at the present time; history is said to consist essentially of human biography, and certainly industry is a living witness to individual acumen and a record of human achievement.

It is no disparagement or adverse criticism to point out that liability to err is human, mistake and misjudgment are implicit in the term, the marvel is that both are so rare in important connections, and engineering effort has a wonderful record in just this particular. It is not that the engineer is less human, but that standards are set so high in his profession that the less competent rarely reach responsibility where mistake means catastrophe.

Industry exists to produce goods of utility, it also exists to produce men, dependable, skilled and trained; the two are intermixed and mingled, both are evident, and it is doubtful if the man gets as much consideration as the product he makes, more especially in the humbler ranks. For positions where large issues are involved human characteristics get the consideration they deserve, yet human material of good quality is never unimportant; intelligence is to be preferred to ignorance at any level. Industry has now reached a point where human considerations are outstanding, to mishandle the situation in the belief that production or profit is thereby served is to produce eventual catastrophe. The solution of present troubles, industrial and otherwise, needs more than common ingenuity; the variables are many, their expression is involved, the factors are numerous, the terms are subtle, the apparent form irregular; yet the same patience and ingenuity which have divested material problems of their mystery can rob impending disaster of its terror and present stable conditions once again.

We have now to reconsider the human problem in industry, grant much formerly withheld, sanction a great deal hitherto prohibited, more than all the humanity of the individual cog in production must be recognised. It is less revolt than evolution which is in progress; it is true there are more disturbing portents latent, but these can be kept in check if industry becomes more humane. There is a time when not to yield is weakness, and it does not follow that greater freedom means lessened output or that advantage is certain to result from privilege; in any case human considerations are going to play an increasing part in the vast and complex organisation known as modern industry.

In the immediate future no less than in the recent past the personal equation will demand, and by necessity will receive, detailed study; the paternal attitude has vanished, in its place must come a new spirit, a new incentive to effort; towards that end human relationship must be built, the goodwill of any business is largely within itself, and is not wholly external to its own staff.

Man and machine are equally wonderful pieces of mechanism, the latter mainly because it was produced by human agency, the greater must include the less, hence it is man who is the prime industrial product.

X-Rays by 300,000 Volts.—Making use of a special transformer for currents of 310,000 volts maximum, F. Dessauer and E. Back (*Deutsche Physikal. Gesellschaft*, 1919, pages 168 to 200) observed, with the aid of a Seemann spectrograph and Coolidge tubes, X-rays of the very small wave-length of 0·057 Angström unit. The line 0·075 A.U. accurately determined was produced by currents of 170,000 volts, and the wave-lengths measurement agrees with the value of 0·072, calculated after Planck-Einstein. The scattering of these very hard rays by aluminium was specially investigated, Dessauer transformer was described in the *Elektrotecknische Zeitschrift* of September 19 and 26, 1918, and that publication called forth a good deal of theoretical controversy.

Water Resources in Queensland.—According to the *North Queensland Register*, the water resources of Queensland obtained by boring are of vast importance to that fertile Australian State, and expert testimony upon the conditions underlying this supply is of great interest, not only to those who depend upon them for their means of irrigating the country, but also to engineers engaged in supplying the equipment for this natural resource. An artesian expert writing on the subject says: "My experiences with the bores lead me to the following conclusions, which have been proved correct by boring: When years ago artesian bores were first put down it was the custom to drill a hole an inch larger than the casing, so that the casing would go down easily. This has to be done now. When another layer of casing had to be put in it was just lowered down to where the first lot had struck, and drilling continued. When the flow was struck it came up the casing, and it also came up the space around the casing to the higher sand levels. In time this constant friction of the water made the passage much larger, and in consequence the flow decreased. Now this escaping of the waters to these higher sand levels has done an immense amount of good, as it has put large supplies of subartesian waters where none existed before. I have got the records of artesian bores put down which went through huge dry sand drifts. These bores have a diminished flow, but the sand beds are now full of water, and bores being put down all over them give pumping supplies from 10,000 gallons to 20,000 gallons per day at a depth of from 80 ft. to 200 ft. There is no waste, and it is comparatively easy and cheap to put down 20 of them.

CONVEYOR INSTALLATION AT THE MAYPOLE MARGARINE FACTORY, SOUTHALL.

CONSTRUCTED BY MESSRS. W. AND C. PANTIN, ENGINEERS, LONDON.

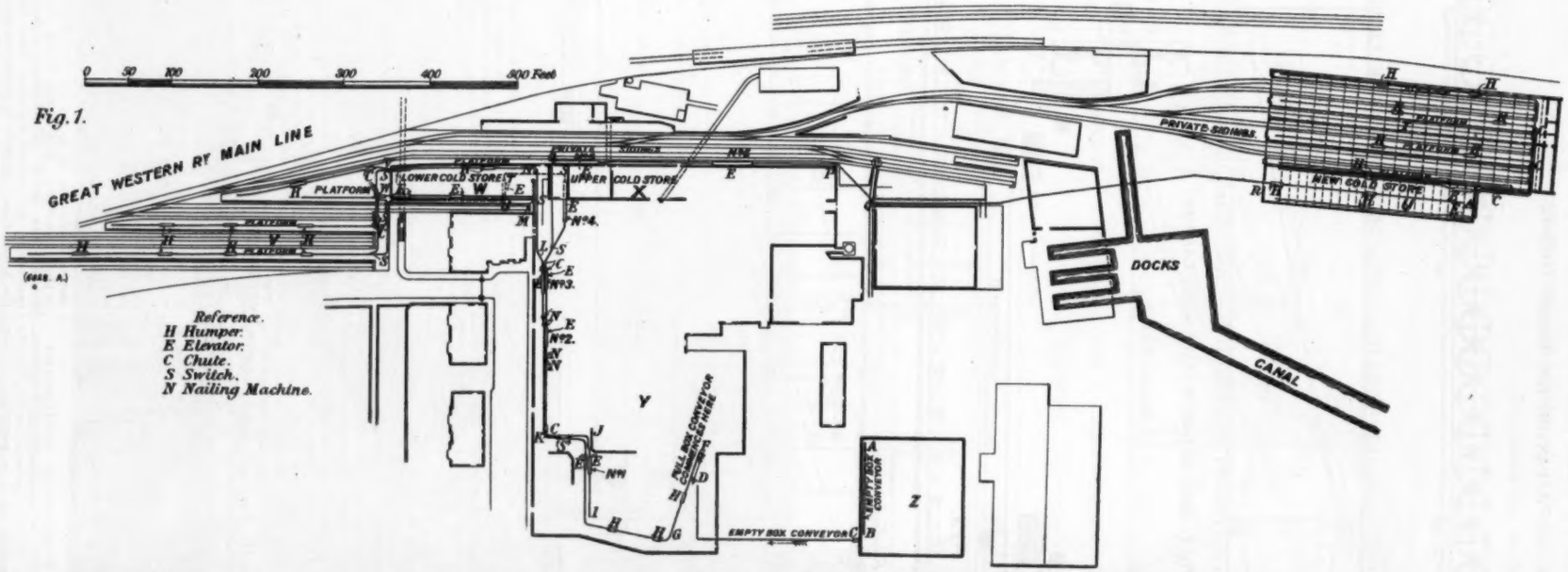


Fig. 1.

CONVEYOR INSTALLATION AT THE MAYPOLE MARGARINE FACTORY.

By GEORGE F. ZIMMER, A.M.Inst.C.E.

We begin in this issue complete illustrations of a comprehensive conveyor installation which has been installed for the Maypole Margarine Works, Limited, in their factory at Southall, Middlesex, by Messrs. W. and C. Pantin, of London. It is necessary before entering into particulars of the methods adopted for handling the output from the factory to give an idea of the extent of the factory and the lay-out.

The factory is believed to be one of the most extensive in this country. The area is about 40 acres, a great portion of which is covered by buildings. The first section was built ten years ago, but considerable extensions have recently been made to cope with the urgent necessity for an increased output of margarine to meet the conditions resulting from the war. These extensions necessitated the provision of new buildings and the introduction wherever possible of labour-saving devices to deal with the average weekly output of over 3,000 tons of margarine, all of which has to be packed in boxes and placed in cold storage before it is despatched. The standard boxes are made to hold 28 lb. and 56 lb. of margarine, and have a gross weight of 30 lb. and 60 lb. respectively. The measurements of the boxes are 12 in. by 10 in. by 8 in. and 22 in. by 14 in. by 8¼ in. About 100,000 56-lb. boxes of margarine are always in stock in cold storage, and the average daily output of the factory is equivalent to 20,000 60-lb. boxes, all of which are handled and distributed through the factory by means of the mechanical conveying plant to be described. On a recent visit to the factory no less than 370 railway wagons were loaded with margarine and despatched from the two private goods stations of the company.

The actual manufacture of the margarine is performed in a comparatively small area, and only a few machines are utilised, whereas the weighing and packing into the boxes occupies so many hands, and results in the work being spread over a floor space so many times the area of that used for the actual manufacturing processes that mechanical handling appliances are not only necessary but essential for economical and quick transit within the packing section, into or out of the cold storage buildings, and on to the despatch platforms.

The key-plan, Fig. 1, on this page, shows the relative position of the buildings, and a study of it will show that the proposition of handling the boxes, although extensive, is comparatively a simple one. The lay-out and details for a large installation such as this one must be arranged to meet the requirements of the service to be rendered, but as a number of the appliances have been standardised and occur many times in such a large plant, it will be useful to refer to these items now and then proceed to describe how they are introduced to produce an efficient conveyor system.

The conveyors in Figs. 2, 3 and 4, page 782, show the design of the wheel carrier type used between points A, B, C to D. The wheels are 2½ in. diameter, run on ball bearings and are fitted with either two or four rows of wheels as required to accommodate the dimensions of the box to be dealt with. This type of conveyor is used when the material or box to be handled is light—in fact, too light to have sufficient grip to revolve the rollers of the standard conveyors. The empty boxes will revolve the wheels easily and descend on the same gradient and as fast as filled boxes will do on the rollers, but the wheels are not rigid enough to support heavy objects such as full boxes.

The gravity conveyor shown in Figs. 5 to 8 has been used throughout the remainder of the scheme. It is of the roller type. The rollers are 2½ in. diameter by 14 in. long. They run on ball bearings and are spaced at 3 in. to 6 in. centres. Each section is 8 ft. long and is provided with fish-plate joints. As a general rule the curves are of 5 ft. radius and are fitted with steel tapered rollers $3\frac{1}{16}$ in. diameter at the large end tapering to 2½ diameter at the small end. It is found that this gives the necessary momentum to the object when passing round the curve. The rollers in such a conveyor have to stand hard service, and are assembled in the frame by placing the axles in the grooves provided; thus each axle acts as an additional cross brace to the frame. Mathews' standard flat lock rails are bolted into position, one on each side of the frame. The balls for the bearings in the rollers are ¼ in. diameter and made of high-grade steel. The ball race is not fixed to the spindle, so that whilst the rollers rotate rapidly on the ball race, the ball race rotates slowly on the spindle, and thereby distributes the wear evenly around the ball race; the spindle is stationary in the frame. The ball bearings run satisfactorily for years without being oiled, but if the conveyor is fixed in the open, oil is applied.

The conveyors are erected at an average gradient of 3½ per cent. throughout, with a minimum of 2·8 per cent. in the installation with which we are now dealing. The power elevators are of two types, the humper or small elevator shown in Figs. 9, 10 and 11, page 783, and the elevator shown in Figs. 12 and 13, on Plate XLV. The designs have been standardised, but in the case of the latter the spread and therefore the amount of elevation, is made to meet the requirements. All are built up of steel angles and flats and are riveted up.

The humper or small power elevator shown in Figs. 9 to 11 is used for renewing the gradient and raises the boxes from a minimum of 1 ft. 6 in. to 4 ft. 8 in. above floor line. The track consists of beech slats, 19¾ in. by 3¼ in. by 1 in., attached by means of standard fittings to a double line of No. 57 chain. Each fifth slat is provided with a 1½ in. angle steel in order that the boxes may not slide backwards. All the bearings are of the ring-lubricated type. The drive for the sprocket wheels is arranged as shown on the illustrations, the electric motor driving on to the 20 in. pulley. The motor is of 1 brake horse-power and the speed of the chain 80 ft. per minute. The appliances for adjusting the tension on the chains are fitted at the lower end of the humper.

An elevator which is typical of those installed is shown in Fig. 12. The boxes are received at the loading end at 1 ft. 8 in. above floor line and delivered to the conveyor at a height of 23 ft. 3 in. The elevator, which is No. 5 on the key-plan, Fig. 1, has a spread of 53 ft. 9 in. The track for this type of elevator, Figs. 14, 15 and 16 (on Plate XLV) consists of slats 22 in. by 4¼ in. by 1 in., attached to a double line of No. 79

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Fig. 2.

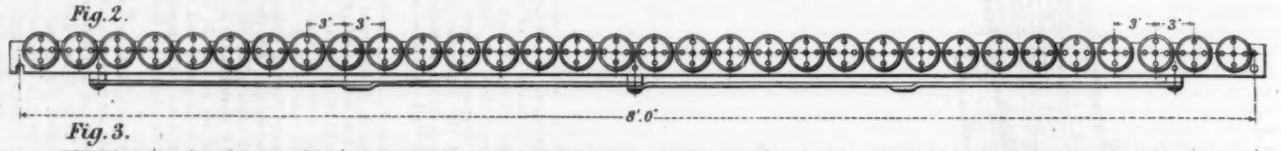


Fig. 3.

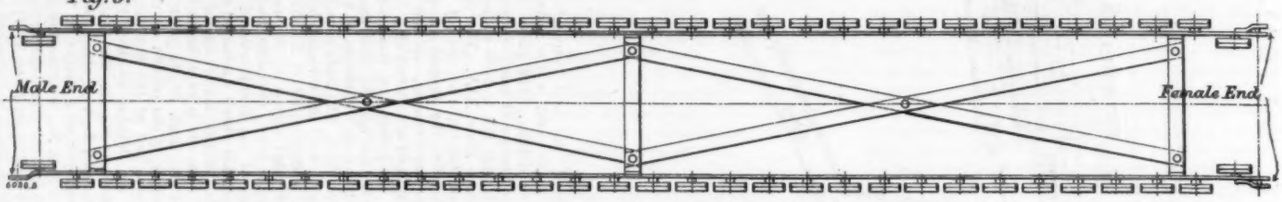


Fig. 4. CROSS SECTION OF LIGHT WHEEL CARRIER.

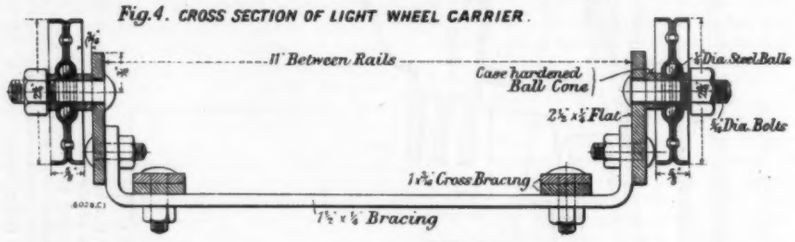


Fig. 5.

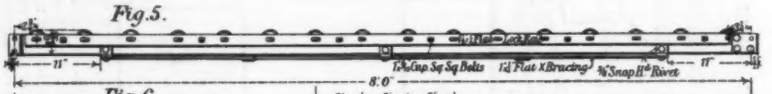


Fig. 6.

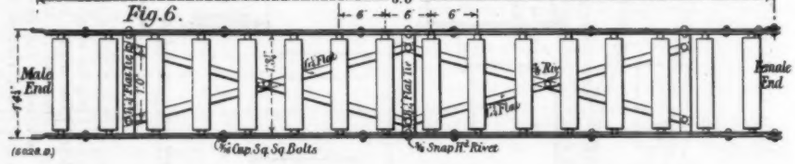


Fig. 7.

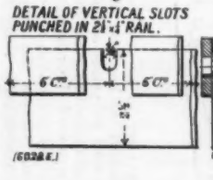
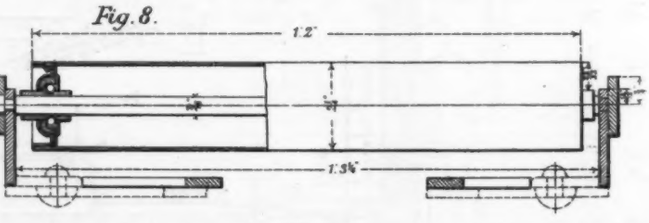


Fig. 8.



chains. Between the bars of every alternate link is fitted a 3½ in. diameter roller, and the sprockets are gapped out to receive the rollers. In the upper terminal a ratchet wheel and pawl is fitted in order that the elevator can only travel in one direction. This prevents the elevator, and therefore the boxes, from running backwards in case of an accident to the driving gear. The power taken by these larger elevators varies. For instance, elevators Nos. 5 and 6 are fitted with motors capable of giving 5 brake horse-power, whilst elevators Nos. 1 and 2 require motors of only 2½ brake horse-power. The half-round guard rails on the elevators, fixed at from 1 ft. 4½ in. to 1 ft. 11½ in. in the clear, are so placed to ensure that the boxes are delivered in the centre of the gravity conveyor.

The arrangement of the cross-over switches and junctions is shown in Figs. 17 and 18, Plate XLV. The design is such that the boxes may be diverted from either of the duplicate runs of conveyor on to the other. The transfer is effected by fitting a movable section of conveyor in each run. This movable section has a hinge at one end in the position shown and castors at the other. These rest on the switch table. The section can be easily moved in a horizontal plane, and when thrown over, delivers the boxes on to the Y junctions built into the run of the conveyor. Fig. 18 also illustrates curves of various radii and a set off. The former vary from 5 ft. to 10 ft. radius.

Having described the principal details used in the installation, it is necessary to refer back to Fig. 1, the key plan, in order that their function and position may be followed. On this plan the route of the conveyors is shown by a full line, the humpers (Fig. 9) are indicated by small rectangles marked H, the elevators (Fig. 12) by the letter E, and the cross-over switches (Fig. 18) by the letter S. Altogether there are about 4,000 ft. run of conveyor, 40 humpers and 14 elevators in the scheme.

The boxes take the following route in passing through the factory:—They are made in building Z; on completion they are put empty on to the conveyors of the wheel type (Fig. 2), A to B and C to D, by which they pass into the main building Y, where they are paper-lined, filled with margarine, and in due course are placed on the roller conveyor of the gravity type (Figs. 5 to 8) between the points F, G and I. In this stretch they pass over the humpers H and elevators E to the nailing machines N, where the covers of the boxes are nailed on. The filled boxes then pass on to the upper or lower cold storage buildings X and W, and eventually out to the loading platforms V, or alternatively to the more recently-erected cold storage building U and loading platforms T.

There are many types of labour-saving devices for handling goods, but, for a scheme such as this and where the boxes are of uniform size and weight, the gravity conveyor has many advantages on account of its simplicity, accessibility and small consumption of driving power. Further, it was found to be very suitable for the lay-out, as it avoids the necessity for high lifts, a consideration when girls are employed. As illustrations of this point, attention is drawn to section F, G to I on the key-plan, Fig. 1, where the conveyor is maintained at a low level, and on this account the three humpers H, H, H are introduced in close succession to renew the gradient and so keep the full boxes moving. Again, on the despatch platforms, lettered T and V, on Fig. 1 the conveyors are maintained at a low level so that the transfer of the boxes to the railway trucks may be effected at practically any point along the length of the platform.

Taking a typical length in the filling and nailing sections of the main building the methods of supporting the conveyors and elevators are clearly shown, and the leading particulars given on the illustrations, Figs. 19 to 22, Plate XLV. On these and other drawings, to be published with our next article, are shown the more complex parts of the installation and the methods adopted for the introduction of the standard appliances and the arrangements which have to be made for supporting the structural work from the floor, roofs or walls of adjacent buildings. Figs. 19 to 22 give these particulars for the section I, J, K to L (Fig. 1). The method adopted at L by the introduction of the two Y junctions at the top of the elevators in conjunction with the lifting section and shoots is interesting. The arrangement allows both runs to be worked at the same time and to feed into either the upper or lower cold stores or alternatively *via* the switch and new conveyor to the new cold-store. Fig. 23, opposite, illustrates the bend leading on to the humper. This illustration is from a point near G. Fig. 24, page 790, shows the two conveyors leading on to the elevators, No. 1, and Fig. 25 is a view of elevator No. 2, with elevators No. 3 in the background.

(To be continued.)

The Allgemeine Elektricitäts Gesellschafts.—A dividend of 10 per cent., as compared with 14 per cent. for the previous year, has been declared for the financial year 1918–1919, a result which is regarded as very satisfactory, considering the results obtained by other large concerns. The surplus for the year was 27,031,546 marks, or some 10,200,000 marks less than the previous year. The 10 per cent. dividend on a share capital of 200,000,000 marks, represents 20,000,000 marks, leaving 7,000,000 marks for various purposes. Considering that the increased expenditure during the last year on wages and gratuities alone amounted to 120,000,000 marks, the shareholders apparently have no cause for complaint. The company, on account of its careful financial policy in the past, of always providing ample funds for reserve, is better able to face an unfavourable year or two than other industrial undertakings, though whether this policy has been departed from in the past year is not apparent at the moment. Owing to the increased disbursements for wages and the increased cost of raw materials, the liquid capital has diminished, and the company has decided to issue debentures for 100,000,000 marks. On June 30, 1918, the debentures issued by the company amounted to 104,530,500 marks.

Proposed Association of United Kingdom Manufacturers.—It has been felt for some time in South Africa, according to *The South African Mining and Engineering Journal*, that there is a need for a representative organisation to look after the interests of United Kingdom manufacturers and to bring their representatives together, and a movement is on foot for the establishment of such a body. It is proposed that the membership should be composed of United Kingdom manufacturers exercising a vote by proxy through their local agents or branches, and, under certain conditions, of agents for United Kingdom firms in their own right. H.M. Senior Trade Commissioner in South Africa, Mr. W. G. Wickham, is interested in the movement, and United Kingdom firms who think that the Association is likely to be of advantage to them might do well to communicate with him (P.O. Box 839, Johannesburg) or with their local agent or branch.

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(*For Description, see Page* 781.)

Fig. 9.

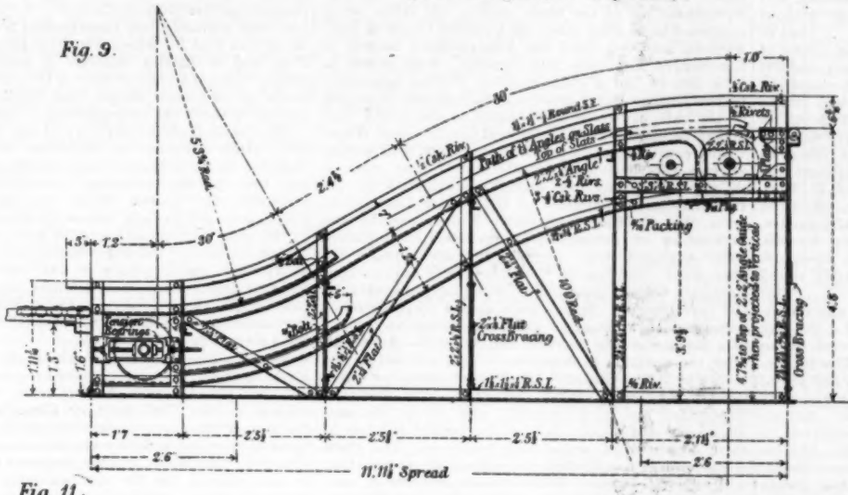


Fig. 10.

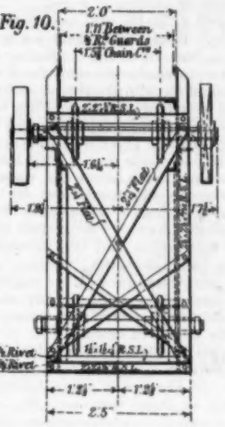


Fig. 11.

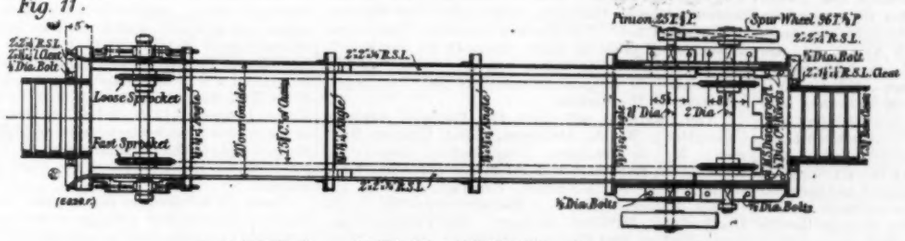


FIG. 23. BEND AND HUMPER IN THE FILLING ROOM.

MIDDLESBROUGH PIG-IRON SHIPMENTS.—Messrs. William Jacks and Co., 5, East India Avenue, E.C., state that the shipments of pig-iron from Middlesbrough, including Skinningrove, in November last were—coast-wise 2,535 tons and foreign 21,938 tons, a total of 24,473 tons, as compared with 20,541 tons in October, 31,070 tons in November, 1918, and 23,638 tons in November, 1917.

INDUSTRIAL NOTES.

THE eighty-first quarterly balance-sheet and report, dated September 30, recently issued by the General Federation of Trade Unions, states that the financial position of the General Federation will need to be carefully considered in the near future. In order that an effective reserve may be accumulated, it is essential, the report adds, that the present rates of contributions in proportion to the benefits paid should be revised, if only temporarily. The tremendous risks of lengthy disputes at the present day and for some time to come will test the weak links in the Federation Rules, "and we must rise to the occasion and strengthen the structure that it may endure the passing storm." The report further states that the present fees do not seem adequate for the liability maintained; it takes two and a-half years to accumulate sufficient funds to pay one week's benefit in the event of a dispute, and earnest consideration should be given to this position by all affiliated members. The Management Committee have considered 74 disputes during the quarter, involving 9,591 members, an average of 129 members involved per dispute. The total benefit paid out for the quarter was 17,370*l.*, considerably less than for the previous quarter, when over 32,000*l.* was disbursed. The contributions for the quarter amounted to 20,698*l.*, an increase of nearly 4,000*l.* on the last quarter. The report hopes to impress upon the large number of trade unions remaining outside the scope of the activities of the General Federation, the necessity for closer unification of the forces by affiliation with the only real and useful national dispute organisation. The General Federation now comprises 183 unions, having a total membership of 1,365,225, and the funds in hand at the end of the quarter, September 30, 1919, amounted to 246,133*l.*

Mr. W. A. Appleton, secretary of the General Federation of Trade Unions, has issued a report of his recent journey to the United States, when he visited the International Labour Conference at Washington. The following are extracts from the report: "What may result from the conference is an arrangement by which the exhaustive effects of work may be ascertained and the real value of work determined. Generally it was agreed that humanity demanded the abolition of conditions which destroy health and happiness, but that the world is so short of necessaries that it cannot continue the support of the idle. Each nation, it was thought, may be expected, at least for many years, to guard jealously its right to work

out its own salvation in accordance with its national circumstances and opportunities. . . . Of the industrial situation in America, it is necessary to speak with the greatest diffidence. As it exists to-day, it is reflected in the police strike at Boston, the steel strike and the coal strike. The first was broken. . . . Reports concerning the steel strike are conflicting, and an outsider cannot discuss the situation without running the risk of making it worse. . . . Coal in America, as well as in Britain, has been the source of infinite trouble. Here, again, there are many conflicting statements, but out of the confusion of utterance, of charge and counter-charge, come facts which justify the men's demand for additional pay, and which vitiate the charges of breach of contract. They have received no recent advances in wages, though cost of living has increased very much. Their war-time agreement was to last until the end of the war or until March 31, 1920. . . . it governed both prices and wages. Had the agreement been loyally continued by all parties, neither prices nor wages could have been altered. The Government, however, permitted the operators or owners to raise prices, and this immediately raised dissatisfaction amongst the miners. . . . Unfortunately, their demand for higher wages was accompanied by a demand for a 6 hour day and a five-day week, and this dual demand was complicated by an outside cry for nationalisation. . . . The injunction is a weapon against a strike, which is not yet in operation in Britain. It is brutally unfair and may some day involve America in grave disorder. Anyone who disregards an injunction may be committed to jail, not for striking or advocating a strike, but for contempt of court. He has no acceptable defence. . . . The mentality of the American has always made for production; now it makes for production plus style and quality. . . . The lightning strike does not appear to be popular with Americans. On the contrary, it is the proud boast of some trade unions that they have never broken a contract. Whether it is good or bad they honour it. If it is bad, they seek to alter it at the proper time; if it is good, they seek to continue it or improve it. . . . American trade unionists will go a long way to improve wages and conditions, but they will not go an inch to hurt America. . . . The strength of the national spirit and the need for it will make the task of forming a political Labour party very difficult indeed. Any party or cause having an anti-national basis will meet with tremendous opposition from the millions. . . . The stability derived from a virile nationalism is greatly strengthened by the broadness of the agricultural basis upon which the nation rests; it is asserted that 60,000,000 people are engaged in agriculture or its auxiliary occupations. . . . America will not escape trouble. When the exchange value of the pound note falls below four dollars, Britain will have to starve a little or find cheaper sources of supply. In either case, America will be hard pressed to find remunerative work for her industrial population. . . ."

The Ministry of Labour has announced that in pursuance of the Industrial Courts Act, which authorises the Minister of Labour to constitute a standing Industrial Court for the purpose of dealing with trade disputes which, with the consent of the parties thereto, may be referred for settlement by arbitration, the following have been appointed to be the first members of this Court: Sir William W. Mackenzie, K.C., K.B.E., president; Mr. F. H. McLeod, C.B., chairman; the members being Mr. D. C. Cummings, C.B.E.; Mr. J. McKie Bryce; Mr. Ernest J. Brown; Mr. F. S. Button; Miss Violet Markham (Mrs. James Carruthers); Miss Cecilie Matheson. The secretary is Mr. G. T. Reid, and the assistant secretary Mr. R. J. Humphreys.

The strike of the ironfounders has entered upon its twelfth week, and there is a fear of its extending, since the moulders have decided to call a conference next week of all the foundry unions with a view to taking joint action. The employers have maintained their stipulation that resumed negotiations can only take place after a resumption of work. There is some hope that the offer of the Federation of Engineering and Shipbuilding Trade Unions will be accepted. On the other hand, it is reported that the Scottish Central Ironmoulders and General Ironfitters' Association have accepted the masters' offer of a 5*s.* increase weekly to all over 18 years of age.

Speaking in Parliament last Monday, Sir Eric Geddes, the Minister of Transport, made the following statement with reference to the negotiations in regard to the railways: "There are three aspects of the position. The first point is the present negotiations on wages. On this no public statement can yet be made. I fully appreciate the anxiety of the House, and will make one at the earliest moment possible. The second point is that an arrangement has been come to between the Government and the two unions concerned as to the grading of men on the railways, to the effect that apart from the present negotiations, questions of wages and conditions of service shall, during the period of the present control of railways under the Ministry of Transport Act, be dealt with by a Central Board consisting of five railway managers and five representatives of the trade unions, the latter being composed as to three from the National Union of Railwaymen and two from the Amalgamated Society of Locomotive Engineers and Firemen, with power to each side to add a sixth member. Failing agreement by this Central Board matters in dispute and belonging to the category mentioned—namely, wages and conditions of service—will be referred to a National Wages Board, consisting of four railway managers, four railway workers (or their representatives) and four users of railways, of which one shall be nominated by the Parliamentary Committee of the Trades Union Congress, one by the Co-operative Union, one by the Federation of British Industries after consultation with other industrial organisations, and one by the Associated Chambers of Commerce after similar consultation, with an independent chairman appointed by the Government. It has been agreed by the unions concerned that no strike shall take place on account of a dispute arising on these matters until one month after the question in dispute has been referred to the National Wages Board. Local committees, to which matters of purely local and other than national importance are to be referred, will be set up, and discussions are taking place at the present time as to their constitution, scope and functions. The third matter which has formed the subject of conversation with the railwaymen is their representation in connection with the control exercised under the Ministry of Transport Act. The Railway Executive Committee, as such, will cease to exist, probably on January 1, and an Advisory Committee will then be set up. It will consist of 12 general managers and four representatives of the workers.

"The following will form the Railway Advisory Committee: Mr. A. Aldington, Great Western Railway; Mr. J. Bromley, Amalgamated Society of Locomotive Engineers and Firemen; Sir Alex. Kaye Butterworth, North-Eastern Railway; Mr. C. T. Cramp, National Union of Railwaymen; Mr. C. H. Dent, Great Northern Railway; Sir Francis Dent, South-Eastern and Chatham Railway; Sir Sam Fay, Great Central Railway; Sir William Forbes, London, Brighton and South Coast Railway; Mr. D. A. Matheson, Caledonian Railway; Mr. F. Tatlow, Midland Railway; the Right Hon. J. H. Thomas, M.P., National Union of Railwaymen; Sir Harry Thornton, Great Eastern Railway; Mr. A. G. Walkden, Railway Clerks' Association; Sir Herbert Walker, London and South-Western Railway; Mr. Arthur Watson, C.B.E., Lancashire and Yorkshire Railway; Sir Thomas Williams, London and North-Western Railway."

The Monmouthshire and South Wales Coalowners' Association have recently issued the following return, showing the total coal output in the United Kingdom for the years 1913 to 1919, inclusive, the total number of persons employed, and the output per annum per person employed. The figures are as follow:—

—	Total Output United Kingdom.	Persons Employed (Underground and Surface).	Output per Annum per Person Employed.
	tons.		tons.
1913	287,411,869	1,127,890	254
1914	265,643,030	1,133,746	234
1915	253,179,446	953,642	265
1916	256,348,351	998,063	256
1917	248,473,119	1,021,340	243
1918	227,714,579	1,008,867	225
1919	*223,315,833	1,130,000	197

* Estimated.

At a special Trade Union Congress held at the Central Hall, Westminster, last Tuesday, the chairman, Mr. J. H. Thomas, M.P., stated that the Glasgow Congress had decided in an unmistakable manner that the mines should be both State-owned and State-controlled. That decision was the considered judgment of an almost unanimous movement. The proposals in regard to the mines were submitted to the Government by the Joint Committee of the Parliamentary Committee and the Miners' Federation; the Government refused to accept the proposals of the Congress. They were therefore called together to determine their future action. Their decision in the matter must not be determined by the consideration of the miners alone, but in the interests of the community as a whole. That was fully realised by the Miners' Federation; they had never put forward the claim of the mines for the miners, but acted on sound democratic grounds of public ownership in the interests of all and as a maximum protection to those primarily affected. It naturally followed that the one sound course of policy was to demonstrate to the public the justice of their methods. In this connection they must not forget the political side of their movement, for it was an instrument which for the purpose could be as powerful as was industrial action; it was not so costly and was certainly less inconvenient to secure by the ballot box that for which men were prepared to strike. Five and a quarter millions of organised workers formed a power second to none in the country, but there would be no greater danger than for that power to be wielded without the responsibility it carried with it.

Mr. Frank Hodges, secretary of the Miners' Federation, after referring to interviews with the Prime Minister on the subject of nationalisation of the mines said that the Parliamentary Committee, the miners' executive, the Labour Party and the Co-operative Party proposed to have before Christmas, in addition to the great demonstration to be held after the sitting then being held, six demonstrations in six large towns; in January and February it was hoped to hold one hundred demonstrations in as many large towns. The funds required for these was to be subscribed by the Parliamentary Committee, the Miners' Federation, and the Labour Party.

Mr. W. Thorne, M.P., speaking on behalf of the Parliamentary Committee, moved:—

"That this Congress, having heard the report submitted by the Parliamentary Committee as to the position of the Government towards the recommendations of the Coal Industry Commission on the Nationalisation of the Mines, and the proposals for a campaign, in the country for the nationalisation of the coal-mining industry, decides to defer its decision until an adjourned Congress, which shall be held after the re-assembling of Parliament in February of next year; and that at such adjourned Congress the Trades Union movement will be called upon to give effect to Clause (*c*) of the Nationalisation Resolution of the Glasgow Trades Union Congress, 1919, unless the Government have, in the interim, decided to introduce legislation accepting the principle of the nationalisation of the coal mines as set forth in the Report of the Coal Industry Commission."

Clause (*c*) referred to states that "in the event of the Government still refusing to accept this position, a Special Congress shall be convened for the purpose of deciding the form of action to be taken to compel the Government to accept the Majority Report of the Commission." The principle of nationalisation, or, as he, Mr. Thorne, preferred to call it, socialisation, had been affirmed by the Congress year by year since 1886, and the issue was now becoming acute.

Mr. W. Brace, M.P., said the Sankey Commission had declared that the old system stood discredited, and it was impossible now for the nation to go back. It must go on to nationalisation. The telephones were controlled bureaucratically. The miners proposed that the mines should be operated by the people who knew best, by a union of labour with the hand and labour with the mind. The miners' proposals for pit committees, district councils, and a national council were based on that principle. The miners were prepared under their scheme to accept a minority representation on these bodies and to give the consumers a voice in fixing the price of coal. They proposed also to set up a Ministry of Mines.

After speeches by Mr. Tom Mann, general secretary of the Amalgamated Society of Engineers, and Mr. J. Jones, M.P., Mr. Smillie, president of the Miners Federation, said that to him the greatest of all reasons for nationalisation was that they might be able to reduce the death and accidents rates of the mines, and that would not be arrived at so long as the mines were controlled and worked as they were at present. Unless the mines were nationalised, action would be taken, and it would be constitutional action; the great trade union movement was perfectly entitled to use its power to force the Government on a question of that kind.

The above resolution was carried unanimously. The Congress then gave its attention to the cost of living, housing, &c.

Active Nitrogen.—Some years ago Professor Strutt (now Lord Rayleigh) discovered that nitrogen, generally a sluggish gas, can be activated by the electric discharge under conditions which are still obscure to a certain extent. The active nitrogen has never been prepared in a pure state, and its constitution is unknown. Max Trantz suggests in the *Zeitschrift fur Elektrochemie* of last September, that active nitrogen is N_3, a body somewhat analogous to ozone O_3, and that at any rate at very low temperature active nitrogen consists essentially of N_3, and at ordinary temperature partly of N_3. He believes at the same time that it will be impossible to prepare pure N_3, because when cooled in the presence of N its active nitrogen passes into N_2, and when heated it decomposes into N_2. Lord Rayleigh's original opinion was that his active nitrogen was simply atomic nitrogen N, not molecular N_2.

NAVY ESTIMATES.

IT is gratifying once more to have the "Navy Estimates" in the well-known form, but it is quite impossible to make any comparison, since the period they cover, ending March next, can scarcely be termed "normal." The total sum involved is 157,528,800*l.*, an increase on the forecast of 149,200,000*l.*, largely due to increased pay, pensions and war gratuities. The total, however, is very favourable compared with the expenditure during the War, when the weekly rate of expenditure reached a maximum of 6,750,000*l.*, immediately prior to the Armistice; this was at the rate of more than 350,000,000*l.* a year. The total for the years of war is now stated to be as follows:—

	£
1915–16 ... ... (net)	205,733,597
1916–17 ... ... (net)	209,877,218
1917–18 ... ... (net)	227,388,891
1918–19 ... ... (estimated)	325,000,000

There is every probability of a reduction in the near future, as there has been a great diminution in the number of ships built. An interesting table given in the First Lord's statement has reference to the revision in the shipbuilding programme.

Revision of Shipbuilding Programme.—Of the vessels under construction at the time of the Armistice, those were completed whose construction had proceeded so far that cancellation would have been uneconomical having regard to the possibility of their useful employment upon naval and other work. The following table shows the numbers involved and their disposal according to their various classes:—

Type.	Ordered and under Construction 11.11.18.	Since Cancelled.	Completed 31.10.19.	To be Completed.
Battle cruisers	4	3	—	1
Light cruisers	21	4	8	9
Flotilla leaders	11	4	4	3
Destroyers	97	40	41	16
Patrol boats	1	—	1	—
Submarines	73	33	20	20
Aircraft carriers	2	—	—	2
Minelayers	2	2	—	—
Twin screw mine sweepers	90	36	57§	6
Paddle mine sweepers ..	5	5	—	—
Patrol gunboats	56	31	24	1
Trawlers	259	215*	44	—
Drifters	206	173†	31	2
Boom defence vessels	29	1	26	2
Tugs	99	43‡	47	9
Seaplane towing lighters ..	23	19	4	—
"2" Class	11	2	8	1
Mooring vessels (excluding motor boats)	7	—	4	3
Totals	1,005	611	319	75

* Including 133 building cancelled for the Navy but completed for private use.
† Including 109 building cancelled for the Navy but completed for private use.
‡ Including 25 building cancelled for the Navy but completed for private use.
§ Including 6 completed as surveying vessels.

Disposal of Ships and Stores.—The following statement gives the number of ships sold by the Admiralty since the Armistice up to November 24, 1919, including obsolete warships sold for breaking up:—

Battleships	2
Cruisers	2
Destroyers	42
Torpedo boats	22
Gunboats	7
Submarines	11
Sloops	2
Whalers	5
Yachts	8
Motor boats	3
Motor launches	67
Tugs	3
Trawlers	167
Drifters	39
Miscellaneous	11
German submarines (sold on Allied account)	56

In addition, considerable quantities of material as part of liquidations of contracts have been dealt with.

Numbers of small craft and large "arisings" from dockyards, ships and local depôts all over the country have been sold by arrangement with the Disposals Board, to whom the proceeds of sale will accrue.

A useful feature of the "Navy Estimates" was formerly, and is still, the dimensions of the ships built, but in view of the comprehensive paper read by Sir Eustace d'Eyncourt before the Institution of Naval Architects, and reproduced in ENGINEERING (vol. cvii, pages 479, 482), it is not necessary here to deal with the particulars given. The only exception is the case of the battle-cruiser Hood, which is now being completed at Messrs. John Brown and Co.'s yard at Clydebank. This vessel was not included in Sir Eustace d'Eyncourt's paper, and the dimensions are therefore given here for the first time. She is the largest warship so far completed, her length being 860 ft., her beam 104 ft., and her mean load draught 28 ft. 6 in., at which the displacement is 41,200 tons. The geared turbine machinery with which she is fitted develops 144,000 shaft horse-power, and the designed speed is 31 knots. Oil fuel is used exclusively, and the capacity at load draught for this fuel is 4,000 tons. Her armament includes eight 15-in. guns, twelve 5·5-in. guns, and four 5-in. anti-aircraft guns. The total estimated cost as revised, including the guns, is 5,458,335*l.*, the estimated cost of the guns alone being 171,000*l.*; this, of course, does not include the mountings. It is anticipated that more than 5,250,000*l.* of the estimated cost will have been spent by the end of March next.

THE CRUISER STERN.*

By Mr. P. A. HILLHOUSE, B.Sc.

THE first large liners to have the cruiser stern were the Empress of Russia and the Empress of Asia, built in 1913, although the coasting steamers Prince Rupert and Prince George had been so constructed in 1910, and the Wilson liner Borodino in 1911. The Empresses were followed by the Allan liners Calgarian and Alsatian, and the fashion spread so rapidly that Lloyd's Register now includes the names of over 150 vessels under the classification of "cruiser stern."

As an example of the advantage obtained by the adoption of a cruiser stern, I present the case of a twin-screw passenger and cargo vessel, 550 ft. in length, in which it is desired to carry 2,800 tons of cargo in addition to passengers, stores, and water, and fuel for a voyage of 3,000 miles, at a mean speed of 18 knots. The particulars of such a vessel, if constructed with the ordinary overhung counter, would be approximately as given in the following table, which also gives particulars of a similar vessel with a cruiser stern:—

	Ship with overhung counter.	Ship with cruiser stern.
Length	550 ft. (B.P.)	550 ft. (nominal)
Length overall	570 ft.	570 ft.
Length on water-line ...	550 ft.	570 ft.
Breadth moulded	70 ft.	70 ft.
Depth to bridge deck ...	54 ft.	54 ft.
Weight of hull	11,200 tons.	11,200 tons.
Weight of machinery ...	2,800 tons.	2,575 tons.
Light weight	14,000 tons.	13,775 tons.
Fuel for 3,000 miles ...	1,970 tons.	1,750 tons.
Fuel for two days spare ...	570 tons.	505 tons.
Fuel for use in port	160 tons.	160 tons.
Total fuel	2,700 tons.	2,415 tons.
Passengers, stores and water	1,500 tons.	1,500 tons.
Cargo	2,800 tons.	2,800 tons.
Total deadweight	7,000 tons.	6,715 tons.
Load displacement	21,000 tons.	20,490 tons.
Load draught (moulded) ...	28 ft.	28 ft.
Load block coefficient ...	·682	·642
Deduct half fuel consumption	985 tons.	875 tons.
Displacement half-way ...	20,015 tons.	19,615 tons.
Draught moulded half-way	26 ft. 10½ in.	27 ft.
Block coefficient half-way ...	·677	·637
Mean speed	18 knots.	18 knots.
Speed-length ratio, $V \div \sqrt{L}$	·768	·755
Horse-power	17,650	15,675
Admiralty coefficient ...	245	272

By replacing the ordinary overhung counter with a cruiser stern the counter will be well immersed, so that both the water-line and the curve of cross-sectional areas can be carried out fairly to the end of the stern, and it is thus possible to add about 20 ft. to the effective length of the ship. The speed-length ratio and the block coefficient can both be correspondingly reduced, with a consequent decrease in horse-power. This saving in power enables us in turn to cut down the weights of machinery and fuel, and so to fine the form still further and save more power. This process can be repeated until at last a balance is reached at the point where the displacement necessary to carry all the required weights is just the displacement which can be driven at 18 knots by the power installed.

In the above table it is assumed that any consumption of stores, domestic water and reserve feed water is compensated for by the addition of salt water ballast for the maintenance of stability and trim, so that the only reduction of displacement that can be taken advantage of in the case of the ship with cruiser stern is that due to consumption of fuel. It will be seen that the adoption of the cruiser stern has resulted in a saving of nearly 2,000 horse-power and of 220 tons of fuel per trip, or about 11 per cent. The area of the upper deck will be increased in proportion to its extra length, as the effect of the lesser block coefficient will hardly be felt in the upper works; the water-line area will be the same in either ship, while the space available for the stowage of cargo will be practically identical in the two vessels, since the capacity lost on account of the fining of the extremities of the cruiser stern vessel will be compensated for by the lesser volume occupied by machinery and fuel. On a shorter trip, from port to port, the economies would not be so great, since the saving in weight of fuel would be less; on a longer voyage still more favourable results could be realised.

The earlier merchant cruiser sterns were associated with the small propellers of direct turbine drives, and no trouble was experienced in satisfactorily housing the propellers within the half-breadth of the ship.

But the progress of marine engineering has rendered the direct drive almost obsolete for merchant work, and standard practice is now to fit either single-reduction or double-reduction geared turbines. The larger propellers so obtained are much more efficient, but it is much more difficult to place them satisfactorily abreast of the cross sections of the cruiser form of stern, and it appears probable that the cruiser stern might never have been adopted for merchant work had its introduction not been facilitated by the small size of the propellers prevalent at the time.

To obtain full advantage of the immersion of the counter it is desirable that both the water-line and the curve of cross sectional areas should be carried without hollow or "tail" right out to the end of the stern profile. With the ordinary stern the propellers were usually placed a few feet forward of the sternpost from which the water-line and area curve begin, and were thus associated with very small transverse ship dimensions. In the case of the cruiser stern, however, the propeller is further forward in relation to the beginning of the area curve, and so comes abreast of a much larger cross-section, and it is consequently more difficult to house it satisfactorily. Baker, in the excellent paper he read before this Institution last February, pointed out that it is desirable to keep the final angle of run of the water-line to about 20 deg., and in any case to not more than 25 deg., from the middle line. We are thus faced with the difficulty of obtaining in way of the propeller a cross section having a narrow water-line (to work in the 20 deg. angle), a large area (to avoid hollow in the curve of areas), and a wide deck (to please the owner and to protect the propeller). A full rounded section will give us deck breadth and area, but not the 20 degs. water-line. A more vertical section will give us the desired water-line and curve of areas, but not the deck breadth. In this case the profile would probably have to be tumbled forward and the deck line made very fine. Another arrangement giving the broad deck and fine water-line, but necessitating a hollow in the curve of areas, can be made, but to obtain all three desiderata we are apparently forced to make the cross-section abreast of the propeller practically straight, and at the same time to place the propeller and rudder as far aft as possible.

Many advantages have been claimed for the cruiser stern in addition to its beneficial effect upon propulsion, and without pressing any of such claims too far I think it can fairly be stated that, as regards cost, strength, stability, seaworthiness, and absence of vibration, the new form is at least as good as its predecessor.

* Abstract of paper read before the Institution of Engineers and Shipbuilders in Scotland, November 25.

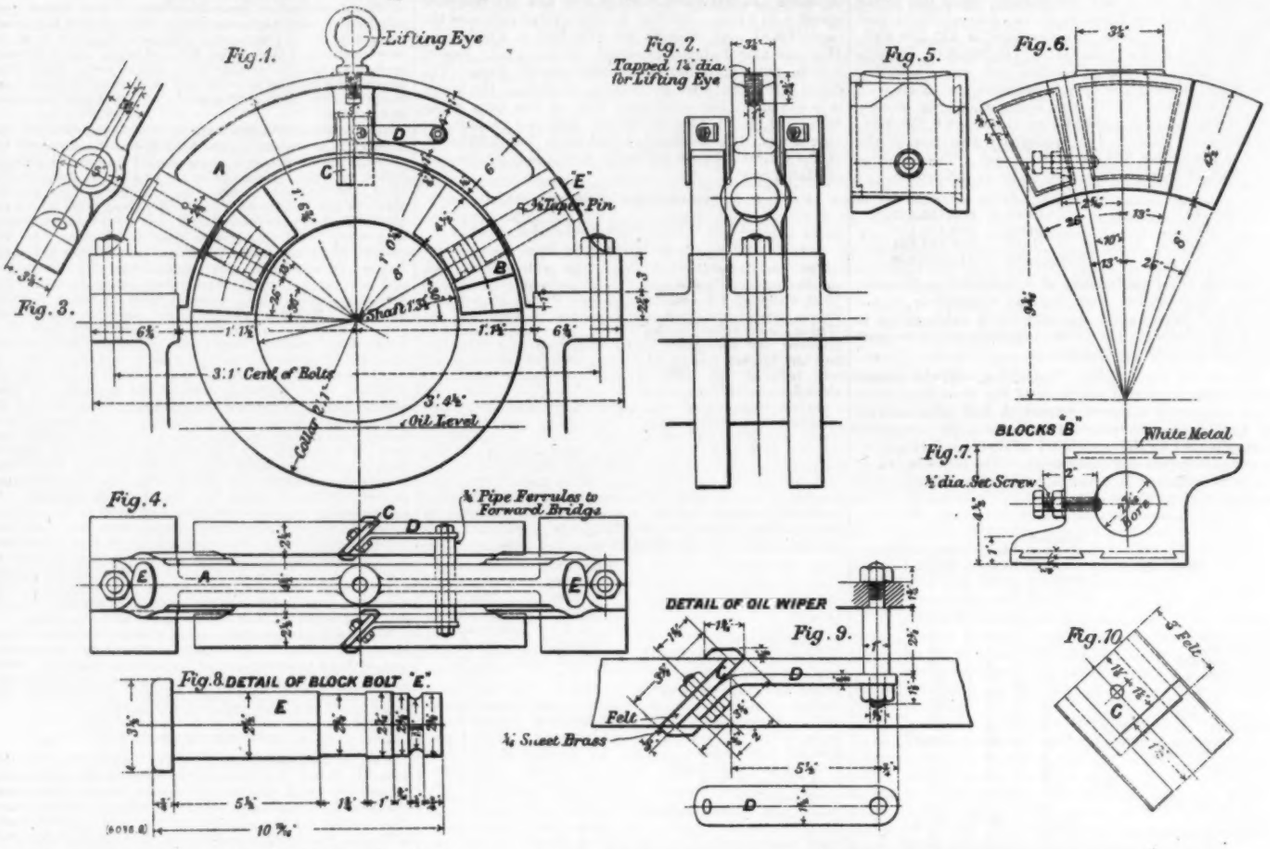
"ROAD REINFORCEMENT."—The twelfth issue of this journal, dated November, gives illustrated information on the use of B.R.C. fabric by the British Reinforced Concrete Engineering Company, Limited, Trafford Park, Manchester, for the laying of strong and durable roads. A special Road Congress number, also dated November, contains interesting illustrated particulars on the same subject. Both numbers show reinforced concrete roads completed and in course of construction.

MARTELL SCHOLARSHIP IN NAVAL ARCHITECTURE (1920).—The Council of the Institution of Naval Architects now offer for competition a scholarship (value 100*l.* per annum for three years) to be awarded on the results of the Board of Education examinations in naval architecture and other subjects. Candidates must be between 18 and 21 years of age. Full particulars and application forms are obtainable from the Secretary, Institution of Naval Architects, 5, Adelphi Terrace, London, W.C. 2. The entries close on January 15, 1920.

PERSONAL.—Mr. William Oliver, B.Sc., A.M.I.C.E., has recently been appointed lecturer in the Organisation of Industry and Commerce by the Edinburgh University Court, after consultation with representatives of the Edinburgh Merchant Company, the Edinburgh Chamber of Commerce, the Leith Chamber of Commerce, the Institute of Bankers in Scotland, and the Leith Shipowners' Society. Mr. Oliver, who was educated at George Watson's College, Edinburgh, and at the Edinburgh University, in which latter Institution he graduated in science with distinction, has been in the employment of Messrs. Bruce, Peebles and Co., Limited, Edinburgh, since he left school, and he now holds the position of contract engineer to that company, which position he will still hold, in addition to the new lectureship. As he has had experience in all the chief departments of Messrs. Bruce Peebles' works and offices, and for some time past has been intimately connected with the commercial side of the business, first as chief of the sales department and now as chief of the contract department, Mr. Oliver's experience will stand him in good stead in connection with the new lectureship in the important subject of the organisation of industry and commerce. There were over 50 applicants for the lectureship.—Mr. Frank Noake has, on the conclusion of his war duties, commenced practice as a consulting and representative engineer, at 21, Waterloo-street, Birmingham. The local interests of Sandycroft, Limited, the Climax Rock Drill Company, Limited, and of Dressler Tunnel Ovens, Limited, will be in his hands.—Mr. W. Hope Wilson, M.I.Mech.E., for many years general manager of the H.S. Engine and Turbine Department of Messrs. James Howden and Co. Limited (and who formerly held a responsible position with Messrs. Willans and Robinson, Limited), has commenced business as a consulting engineer, at 29, St. Vincent Place, Glasgow. In addition to consulting work generally, he will specialise in steam turbines, engines, boilers and electrical power plant, with which he has been long and extensively associated.

MICHELL BLOCKS FOR EXISTING THRUST BEARINGS.

CONSTRUCTED TO THE DESIGNS OF MR. H. T. NEWBIGIN, A.M. INST. C.E., NEWCASTLE-ON-TYNE.



After long years of neglect the Michell thrust block was, during the war, adopted as the standard for use in the Navy. According to the evidence given in the action for the extension of the patent tried before Mr. Justice Sargeant last March, the consequent saving to the nation during the past four years was of the order of 600,000*l*. This estimate was accepted as reasonable by a witness who represented the Admiralty. The saving was in the main due to the reduction in frictional losses, but also in part to the fact that the Michell block works perfectly satisfactorily with a cheaper lubricant than can be safely used with the ordinary multi-collar type of thrust bearing. The Michell block was also, during the war, adopted on a certain number of merchant steamers, but had to contend here with the conviction of most sea-going engineers that it was better to put up with the known defects of the ordinary pattern of thrust bearing than to risk the possibility of the advantages claimed for the new type proving illusory in practice. Indeed, those who had the most experience with the difficulty of making ordinary multi-collar blocks work satisfactorily were the least ready to believe in a single-collar thrust proving anything but a disastrous failure. Indeed, in some cases merchant steamers were provided both with a multi-collar thrust and the Michell type, as the engineers declined to take the risk of passing through the submarine danger zone dependent upon what was to them an untested novelty. On the first out-bound voyage, therefore, the Michell block was not used until the danger from submarines was passed, but on the return trip the engineers invariably preferred to rely wholly on the new type. This they found to give so little trouble and to be so economical of oil that a demand arose for applying the principle to existing thrust bearings.

We illustrate, in Figs. 1 to 11, on this page, the method of doing this adopted on the steamship Hyson, of the Ocean Steamship Company.

As shown in Figs. 1 to 4, the usual water-cooled horse-shoes are replaced by cast-iron arches A (Figs. 1 and 4). On each of these arches two pivoted blocks B are mounted each on a gudgeon pin E, which is shown on a larger scale in Fig. 8. These blocks are of cast-iron faced with white metal, and are illustrated in detail in Figs. 5, 6 and 7. One face of the block is in action in going ahead, and the other in going astern. As best seen in Fig. 7, the pivot for each block lies behind the centre of the working face, this being a characteristic though not absolutely essential feature of the Michell system. Two oil wipers C, shown in position in Figs. 1 and 4 and in detail in Figs. 9 and 10, are mounted on flexible arms D, and embrace the collar as indicated. A view of the complete block is reproduced in Fig. 11, from which it will be seen that six arches with pivoted blocks replace eight water-cooled horseshoes. The blocks were fitted to the vessel whilst in China, and on the run home the chief engineer reports that the temperature of the bearing was never as much as 10 deg. F. above that of the engine-room; it has proved very economical in oil. Guards, not shown in Fig. 11, are fitted to prevent loss of lubricant.

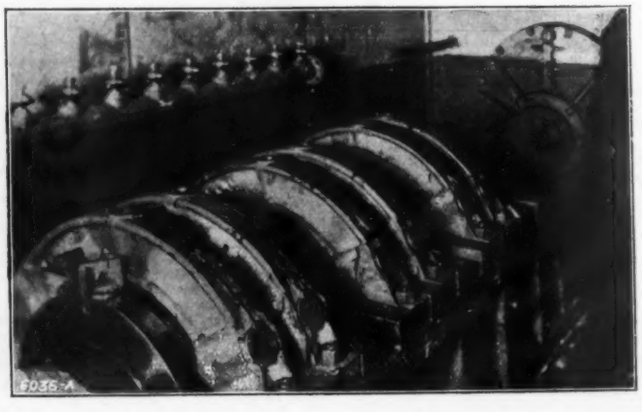


Fig. 11.

The Association of Engineering and Shipbuilding Draughtsmen.—The National Technical Sub-Committee of this association, announces from "Royston," Saunterne-road, Prestwick, Ayrshire, N.B., a series of lectures for the session 1919–20, to be delivered at the various branches—Manchester, Glasgow, Sheffield, Newcastle, Merseyside, &c.—covering a large number of subjects. Further information and a syllabus can be obtained by application to the above address. The head office of the association is at 8, Victoria-street, Westminster, London, S.W. 1.

Light Railways Acts, 1896 and 1912.—The Minister of Transport has recently confirmed the undermentioned Order, made by the Light Railway Commissioners: Liverpool and Prescot Light Railway (Amendment) Order, 1919, amending the Liverpool and Prescot Light Railway Order, 1898, and authorising the Lord Mayor, alderman and citizens of the City of Liverpool to purchase the undertaking authorised by that Order. He has, further, recently confirmed the following Order, also made by the Light Railway Commissioners: Ashover Light Railway Order, 1919, authorising the construction of a light railway in the parishes of Stretton of Sherland and Higham of Brackenfield and of Ashover in the County of Derby.

THREE-DRUM SAND-PAPERING MACHINE.

CONSTRUCTED BY MESSRS. THOMAS ROBINSON AND SON, LIMITED, ROCHDALE.

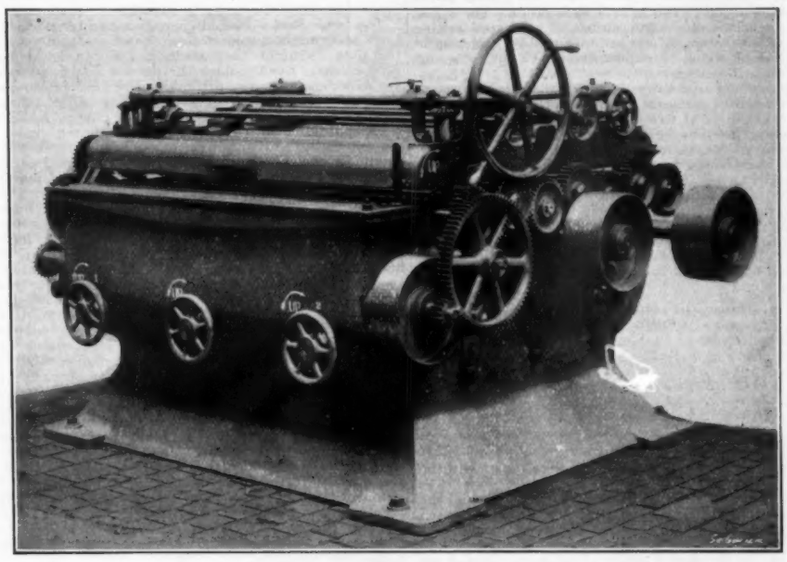


FIG. 1.

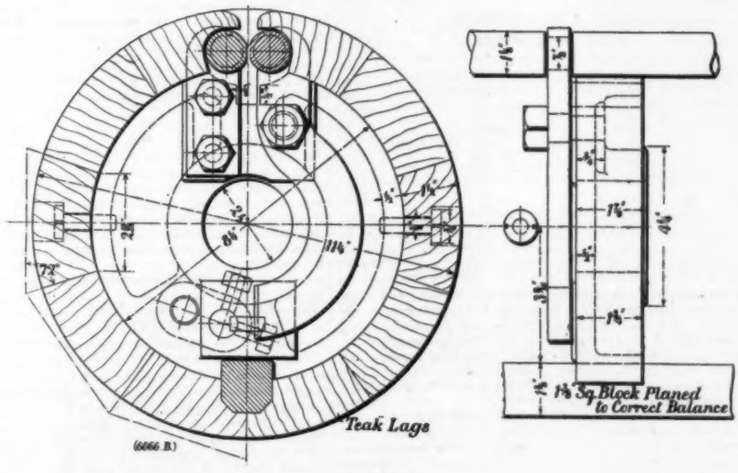


FIG. 2.

IN their comprehensive exhibit of wood-working machinery at the Lyons Fair, Messrs. Thomas Robinson and Son, Limited, of Railway Works, Rochdale, showed the sand-papering machine illustrated by the accompanying engravings. The machine, which is the outcome of the firm's long experience in this class of work, is suitable for finishing all high-class woodwork, especially that of a rather heavy nature, such as is used in railway-carriage construction and shipbuilding work.

The general appearance of the machine is well shown by the half-tone engraving Fig. 1, and it will be noticed that the frame consists of a heavy ribbed casting with an extended cored base, which gives a high degree of rigidity—an important desideratum in high-speed machinery of this class. The most interesting feature, however, is the design of the sanding drums. One of these is illustrated by the drawings reproduced in Fig. 2. These, instead of being made entirely of metal, are built up of teak lags screwed on to four cast-iron discs, which are spaced at equal distances apart on the shaft. This construction, it is claimed, is lighter than the more usual form, and it also gives a more secure attachment for the sandpaper with which the drum is covered. The method of securing the paper is as follows: Two small steel rollers are mounted on the cast-iron discs, as shown in the upper part of Fig. 2, and the rollers, which extend for the whole length of the drum, have a small flat formed on each of them. When fixing a piece of sandpaper the rollers are turned round by means of a box spanner, which fits on to a squared part at one end, until the flats coincide, and one edge of the paper is inserted through a slot in the lags into the space between the rollers. The rollers are then turned round so as to grip the paper between the cylindrical portions and, after passing the paper round the drum, the other edge is inserted between the rollers and secured as above described. The paper can then be made quite tight by turning each roller alternately, and finally secured by locking the rollers at the ends. To enable the distance between the rollers to be increased slightly, so as to accommodate paper of different thicknesses, one of the rollers, that on the right in Fig. 2, is carried by curved levers, as shown in the drawing. The adjustment is effected by means of wedges which bear on ends of the levers, as shown in the lower part of Fig. 2, the wedges being moved longitudinally by means of a screw.

The machine illustrated has three drums carrying paper of coarse, medium and fine-grade, respectively, and the third drum has a covering of soft material under the fine paper to give a perfectly smooth finish to the work. A revolving brush is also provided to remove the dust, and this imparts a certain amount of polish to the wood. The drums are each driven by separate belt pulleys, two of which are visible towards the back of the machine in Fig. 1, while the third is on the opposite side. While working, the drums are given a slight lateral oscillating motion by means of eccentrics, in order to prevent marking of the work. Each drum can be adjusted vertically by means of the hand wheels seen in front of the machine, and means are also provided for rendering them perfectly parallel with the table top. The third pulley, near the front of the machine, is used for driving the feed rollers by means of cut gearing, which is normally completely enclosed, although the covers were removed when taking the photograph from which Fig. 1 was reproduced. There are eight feed rollers, four above and four below the table, and three large pressure rollers are also provided, one being fitted over each of the sanding rollers to hold the work down firmly on to the table. Each pressure roller can be regulated independently by means of a hand wheel. The upper feed and pressure rollers are all carried in a rigid frame supported by four square-threaded screws, the thrust on which is taken on ball washers. The whole frame can be easily and quickly adjusted to accommodate work of different thicknesses by means of the large hand wheel seen in Fig. 1. A graduated scale is provided near this hand wheel to facilitate the work of adjustment.

The machine illustrated is capable of taking work up to 40 in. in width, and 4 in. in thickness. The power required for driving it is approximately 20 brake horse-power. One smaller and two larger sizes are made, and these take work up to 30 in., 50 in. and 60 in., in width, respectively. The maximum thickness of work taken is 4 in. in all cases. Any of the machines can be arranged for electric driving, and an exhaust fan is always supplied for removing the dust.

AIR CRAFT INCIDENCE METER.—The aircraft-incidence meter of Dr. A. F. Zahm, of the United States Navy, is designed to enable the pilot to read at a glance the direction of the flow of air past his machine. It is a balanced weather vane which indicates small changes of incidence. The model illustrated in the *Journal of the Franklin Institute*, of last November, consists of a two-blade weather vane, which is supported on a horizontal pivot at the end of a bracket arm, protruding forward from a strut and adjustable in pitch by means of a clamping nut at its base. The vane has a forward counterweight to ensure static balance and a pointer which moves over a graduated arc; the blades have the sectional shape of an Eiffel wing No. 5, which, at zero incidence, possesses very slight drag and a large increase of lift with slight increase of incidence. In wind-tunnel tests the pointer remained steadily fixed in the wind direction, until forcibly displaced, when it promptly returned to zero. When the instrument was mounted midway between the planes of a flying boat and carried through very still air at three fixed speeds of 55, 65, 75 knots respectively, the incidence varied normally by $\pm$ 0·4 or 0·6 deg., the maximum occasional deviation amounting to $\pm$ 2 deg. Together with a strap to lash it to the machine, the instrument would weigh 1¼ lb.

ACTION OF GASES ON IRON AND ITS COMPOUNDS.—A research on the action of gases, hydrogen, oxygen and nitrogen, on iron (pig, steel, alloys), and its compounds, described by Friedrich Schmitz in *Stahl und Eisen*, of April 10 and 17 (pages 373 to 381 and 406 to 413) indicates that the gases, and hydrogen in particular, will facilitate some metallurgical processes (refining, cementation, hardening) at high temperatures, but give little promise of technical application, since the working with hydrogen in particular at temperatures of 1,100 deg. C. is expensive, difficult, and, in addition, dangerous. For the laboratory, however, the research is of interest. One of the chief points is that in the dissociation of oxygen compounds the dissociating oxygen has to overcome the oxygen pressure of the air if worked in a vacuum, and the opposing pressure would vanish, while in a hydrogen atmosphere any oxygen liberated is at once bound, and the dissociation hence can take place at a lower temperature. The following is a summary of the reactions which Schmitz observed. When hydrogen is passed over glowing iron or bubbled through the molten metal, the non-metals present (carbon, silicon, sulphur, phosphorus, arsenic, oxygen) are converted into gaseous hydrides, the hydride itself dissociates again and some of the nascent hydrogen so liberated can reduce silica, even at 700 deg. C., to gaseous silicon hydride. Iron salts pass into iron and free acid. When iron is glowed in a gaseous hydride, hydrogen is liberated and diffuses into the iron, and an equilibrium is set up for each element depending upon the temperature and pressure. At high temperatures both carbon and silicon will diffuse into solid iron without being themselves first converted into gaseous compounds. When iron containing metalloids is glowed in oxygen, oxide of iron compounds are formed, which, at high temperature, are decomposed into iron oxides and volatile other oxides. A malleable iron can be obtained by means of oxygen and hydrogen from solid pig as well as from liquid iron. Nitrogen has no action on non-metals contained in solid or liquid iron. This last observation is important. It is often asserted that the carbon percentage of iron decreases when the iron is heated in a nitrogen atmosphere. Schmitz finds that this diminution becomes smaller and smaller, as more care is taken to exclude all traces of oxygen, which is always difficult. He made his own experiments on tubular electric furnaces lined with unglazed porcelain.

OILINESS AND LUBRICATION.*

By R. Mountford Deeley.

So far, it would appear that no satisfactory explanation has been given as to what oiliness really is. All that can be said is that some liquids of similar viscosity are not oily in this sense and will not act as lubricants.

Vegetable and animal lubricants are compounds of carbon, hydrogen and oxygen termed esters, formed by the union of alcohol radicles with fatty acid radicles. There are a great number of such fatty esters, several of which generally go to form each lubricant. The alcohol radicle occurring in the vegetable oils and in most of the animal oils is the trivalent radicle glyceryl C_3H_5 and its esters, known as glycerides, may be represented by the formula $C_3H_5R_3$, in which R represents the fatty acid radicle. Olein is the chief constituent of many of the best-known lubricants, such as lard, tallow, neatsfoot and olive oils. Allied to the fats are the waxes, which are esters of mono- and di-valent alcohols, and a few lubricants such as sperm oil belong to this group.

Mineral lubricating oils are of entirely different chemical composition, consisting essentially of hydrocarbons, compounds of carbon and hydrogen, and we labour under the disadvantage of knowing little concerning their ultimate chemical structure. Dunstan and Thole,† however, have considered the peculiarities of these oils and conclude that all good lubricating mineral oils contain unsaturated molecules, though the chemical constitution of a component of a lubricating oil has in no case been established. The unsaturated compounds constitute between 20 per cent. and 40 per cent. of most lubricating oils.

"Apparently the same facts hold good in regard to fatty lubricants. Rape oil, castor oil and olive oil contain in their molecules double bonds, and are superior in body and viscosity to such a saturated product as, for example, tallow.

"In recent years the progress of organic chemistry has largely been due to the realisation that unsaturation, or the possession of residual affinity, plays an all-important part in the reactivity and the very personality of a compound. Colour, odour, taste, physiological activity, and, in a word, all the characteristic properties of bodies are influenced by this condition. It appears now that we may add lubricating ability to the already long list of effects proceeding from this one prime cause."

The relation of colloid chemistry to industrial problems has attracted much attention of late, and in regard to lubrication Dunstan and Thole remark: "Recent work on colloid chemistry points to the fact that heavy oils must be included in the category of iso-colloids, *i.e.*, polyphase systems in which the disperse component is of the same chemical nature as the dispersion medium. W. Ostwald‡ states that whenever a colloid comes in contact with a surface it fails to maintain a uniform special distribution. "On the surfaces of contact the concentration becomes different from that obtaining in the inner parts of the colloid mass. . . . Usually the colloid tends to concentrate on the surfaces." This is known as adsorption, and the phenomenon was first pointed out by Willard Gibbs. Hardy, in a recent paper,§ has called special attention to this. He finds that a true lubricant, a film of the order of 1 $\mu\mu$ thickness is sufficient to cause two glass surfaces to slide over each other with the minimum friction, and concludes "that lubrication depends wholly upon the chemical constitution of a fluid," and that "the true lubricant is always a fluid which is absorbed by the solid face. If this be so, then the problem of lubrication is merely a special problem of colloid physics."

It appeared to the writer that the property of oiliness might show itself most clearly when the two metallic surfaces were in actual contact, and that, therefore, valuable results might be given if the static coefficient of various oils between different metals were measured.

The friction experiments now to be described were made under conditions which insured that the surfaces should be in actual contact, and any differences in the frictional coefficients obtained with the oils tested must have resulted from the contact of the oily metals and not from the viscous flow of the liquid.

The experiments were made with a small hand-driven machine. Three pegs, each 5/32 in. diameter, rested upon the flat surface of a disc of metal, which could be slowly rotated. These pegs were secured, concentrically, to an upper disc which could be weighted as desired, and which actuated a spindle to which a spiral spring and recording finger were attached. When the lower disc was rotated, the pegs were carried with it by the friction until the surfaces slipped, owing to the stress on the spring, and the finger gave the value of the frictional resistance. To damp the oscillations of the finger, the spindle to which the finger and spring were attached was geared to a small train of wheels, the freely-revolving end wheel of the series having a weighted rim to increase its inertia. A pawl and ratchet were also attached to the gear, to prevent the finger from suddenly falling back when the surfaces commenced to slip. By very slowly moving the driving handle the finger was soon brought to the position giving the static coefficient. The movable disc upon which the pegs rested lay in a circular dish, which could be filled with oil.

To insure clean surfaces, or surfaces as clean as possible, the rubbing metals were ground in water with flour of carborundum. They were then polished with fine wet emery cloth, rubbed well in water with a cork to remove as much emery as possible, dried with clean blotting paper, and finally well warmed to get rid of all traces of moisture. The temperature of the surfaces during the experiments varied from 16 deg. C. to 18 deg. C.

When the surface is thus prepared, and no lubricant is used, the static coefficient gets greater and greater as the surfaces continue to rub against each other. The initial static coefficient of a clean surface of mild steel resting upon cast-iron was, in one instance, 0·154, and rose in the course of about 10 minutes to 0·417, and was still rising when the experiment was stopped.

A series of experiments was quickly made with surfaces of mild steel on cast-iron, all quite clean. As the load decreased from 52 lb. to 8·6 lb. per square inch, the static coefficient of friction increased from 0·167 to 0·230, and the kinetic coefficient from 0·175 to 0·229.

Such clean surfaces are very sensitive to any contaminating agency. In one instance such a surface gave a momentary static coefficient of about 0·160. This surface was then breathed upon for about 2 seconds, and a further test then gave a coefficient of about 0·452.

Each friction value given in the tables to follow is the mean of five determinations for each load of 52 lb., 43·3 lb., 34·6 lb., 26 lb. and 17·3 lb. per square inch respectively.

Table I.—*Rape Oil with Mild Steel on Cast-Iron. Surfaces Dry.*

Lb. per Sq. In.	Coefficient of Friction.
Lb.	
52·0	0·205
43·3	0·200
34·6	0·203
26·0	0·208
17·3	0·218
8·6	0·229

The static and kinetic coefficients were practically the same.

Table II shows the static coefficient of friction and the efficiencies obtained for a number of oils when tested between mild steel and cast-iron, and between mild steel and a lead bronze alloy of the following composition: Copper, 85·88 per cent.; tin, 5·71 per cent.; lead, 4 per cent.; zinc, 4·19 per cent.; iron, 0·10 per cent.; nickel, 0·12 per cent.

The numbers representing efficiency were calculated by the following formula:

100 − (static coefficient × 100) = Efficiency.

Table II.—*Surface Flooded with Oil.*

Description of Oil.*	Mild Steel on Cast-Iron.		Mild Steel on Lead Bronze.	
	Static Co-efficient.	Efficiency	Static Co-efficient.	Efficiency
HB. clock oil .. M.	0·271	72·9	0·275	72·5
Castor oil .. V.	0·183	81·7	0·159	83·1
Trotter oil .. A.	0·123	87·7	0·152	84·8
Rape oil .. V.	0·119	88·1	0·136	85·4

* A = Animal oil; V = Vegetable oil; M = Mineral oil.

There is a marked difference between the friction of the various oils when mild steel is opposed to cast-iron and the copper alloy respectively. Rape and olive oil give the best results, and mineral oil the worst, castor coming between the mineral lubricants and the rest. Rape and olive oil are of equal friction-reducing value between mild steel and cast-iron, but rape is the better oil between mild steel and the lead bronze.

It is interesting to note that the static coefficient of those oils which stand lowest on the list and have the smallest coefficients of friction are those which have proved in practice the best lubricants.

The value of the coefficient of static friction as a test for lubricants depends upon whether care has been taken to properly clean the surfaces in contact. It was found that unless the last traces of water were driven off by heating the results were unreliable.

The coefficients of friction given in Table II make it clear that the static friction varies, not only with the lubricant used, but also with the metals in contact.

It would appear that the unsaturated molecules of the lubricant enter into a firm physico-chemical union with the metallic surfaces, thus forming a friction surface, which is a compound of oil and metal. This solid surface would also appear, in the case of metallic surfaces, to be much more than one molecule thick, the oil either penetrating some little distance into the metal, and altering its physical properties, or, as a result of abrasion, forming a paste of metal plus oil between surfaces covered by oil layers one molecule thick. Even when dry such a surface differs remarkably from a clean metallic surface. When the contaminated skin of a metallic surface has been removed by a file, the teeth of the file cut the metal and remove it easily; but if such a clean surface of metal be slightly oiled, or even if the hand be rubbed over it, the file will not cut anything like so freely. Thin films of matter of this kind cannot be wiped off. It is necessary to grind the surfaces under water, or to cut off a thin layer. When a metallic surface is clean, water easily wets it, and the moisture may be readily removed by heating.

Clean metallic surfaces in frictional contact soon tear each other and heat; but when a lubricant is interposed it unites with the metals forming a solid, which is itself a lubricant. If this substance, oil plus metal, should be torn off the surface, fresh oil combines with the freshly-exposed metal. In this way the metallic surfaces are prevented from touching and seriously abrading each other. However, if the load be heavy, the heating resulting from the friction may be so great that the lubricant is destroyed, and the surfaces then seize and abrade each other.

* Abstract of a paper contributed to the discussion on "Lubrication," by the Physical Society, November 28, 1919.

† Journal of the Institution of Petroleum Technologists, vol. iv (1918), pages 191 to 228.

‡ "Introduction to Theoretical and Applied Colloid Chemistry" (1917), page 87.

§ "A Problem in Lubrication," Journal of the Society of Chemical Industry, vol. xxxviii (1919), page 7T.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The improved demand reported for tools and common steel has developed so rapidly within the past fortnight that trade has assumed "boom" proportions. Steel makers throughout South Yorkshire are experiencing a record influx of orders. Business is coming to hand with very little seeking. The difficulty in the majority of cases is no longer how to make the work spin out over a normal week, but how to meet all requirements. Advanced prices appear to be exercising small influence on the market. Consumers, and particularly foreign consumers, urgently require the material and are willing to meet higher charges to secure delivery. France, Belgium and Italy are all considered buyers, while business with the Colonies and South America is distinctly greater. Spain is also negotiating for an increased share of the South Yorkshire output, but business in this direction is held up by high shipping freights. Local makers can ship steel and tools to South Africa—a distance six times as great—at a lower cost than to Spanish southern ports. An average rate to the Spanish southern ports is 95*s.* 6*d.* per ton as compared with 90*s.* per ton to Delagoa Bay. Negotiations have been opened with the Ministry of Shipping with a view to removing this anomaly. The main reasons for the new-found activity in common steels are without doubt the checking of American competition through labour troubles and diminished output in that country, and the insufficiency of Continental supplies. Contract business in crucible steel is quiet. The engineering trade is carrying on with difficulty. Unless supplies of castings are quickly forthcoming, annealing processes will be seriously interfered with. Ten thousand men and 2,000 women, mainly displaced by the moulders' strike, are idle in Sheffield. Distress among them is acute. Children are being fed at the schools through the medium of national kitchens.

South Yorkshire Coal Trade.—Forward business is being held up owing to the widespread confusion in the minds of traders and colliery companies respecting the administration of the new Order. A feeling of unsettlement prevails, and is reflected in the open market. For house coal the demand is much in excess of the supply. Deliveries are coming forward badly. Merchants have many arrears on their books. The whole output of steam fuel is going away on contract account. Cobbles, nuts and slacks are similarly situated. Reserves at works and on the railways are still low. Prospect of augmenting them against emergency is small, while consumption continues so brisk. Quotations:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.*; Derbyshire best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire smal nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Through the continued shortage of trucks producers of pig-iron are having to stock output that is much needed for consumption, and unfortunately there seems little prospect of any early material improvement of means of distribution. There is still insufficient foundry pig-iron to meet requirements, though the scarcity of that commodity is certainly less acute as the result of discontinuance of deliveries to North of England foundries where the prolonged strike of moulders have permitted of accumulation of considerable stocks. Furnaces are working anything but satisfactorily, and as a consequence are turning out small quantities of foundry pig-iron as compared with the make of inferior iron. Forge quality, though abundant, maintains its value. A growing disposition of Continental customers to take forge pig-iron is gratifying, and should lead to expansion of foreign trade. Sales of half foundry and half forge iron to buyers abroad are reported. For home consumption, No. 1 Cleveland pig-iron is 167*s.* 6*d.*, and all other descriptions of Cleveland iron are now quoted 160*s.*; whilst for export prices are put at 5*s.* above these rates.

Hematite Iron.—Business in East Coast hematite continues on a restricted scale. Difficulties of transport hold up home deliveries, and adverse state of exchange is checking shipments to Italy, one of our best customers abroad. Supply is stated to be rather in excess of demand, but makers so far from showing any disposition to lower prices, hint that cost of production may necessitate advance in the near future. No. 1 is 202*s.* 6*d.* for home use, and 207*s.* 6*d.* for shipment to customers abroad.

Manufactured Iron and Steel.—Manufacturers of finished iron and steel are exceedingly busy. They report enormous pressure for delivery, and complain bitterly of inconvenience due to continued lack of trucks. A large export trade could be done if producers were in a position to give deliveries, but very few firms can give such guarantee. Where business is possible, considerable premiums are paid on home quotations. All prices are very strong, and advances for several descriptions of material are announced. Steel plates, &c., are up 10*s.*; angles and joists have advanced by

10s. and 15s. respectively, rails are 20s. down, and sheets have again moved upward. The following are now among the principal home quotations:—Steel ship, bridge and tank plates, 18l. 15s.; steel angles, 18l. 5s.; steel joists, 18l. 5s.; galvanised sheets, 38l.; and heavy sections of steel rails, 17l. 10s.

Foreign Ore.—It is rather difficult to ascertain value of foreign ore. After a lengthy absence of business renewal of buying is reported, and, indeed, some very heavy orders are understood to have been put through, but on what terms has not transpired.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The dislocation of business caused by the recent strike of bricklayers in the Scotch steel trade is gradually being overcome, and the works are now all practically in full working order again. Deliveries are more satisfactory, but there is still a lot of arrears to make up, and every endeavour is being put forth to get abreast of the urgent demand for material. Buyers keep pressing for deliveries, and so urgent is the call from home consumers that foreign markets can get little attention meantime. Both ship and boiler plates are in much request and quite a fair business is going through in the case of sectional material, with export lots amounting to a respectable tonnage. For black sheets the demand shows no falling off, and although prices were raised only about a fortnight ago another advance of 30s. per ton has again to be recorded. The latter was intimated at the end of last week, and the current prices are now as follows: ¼ in., $\frac{3}{16}$ in. and ⅛ in., 26l. per ton; 12/13 gauge, 26l. 5s. per ton; 14/16 gauge, 27l. per ton; 17/20 gauge, 27l. 10s. per ton; 21/24 gauge, 28l. 10s. per ton, all net, f.o.t., works, and for home requirements. For export lots the prices vary from 20s. to 30s. per ton above these figures. The inquiry for shipping lots is good and no check in the flow of business is anticipated through the higher level of prices. In the case of galvanised sheets there is a very fair business passing even with quotations at the present very high values. In the steel trade generally, while the current home demand is very great there are also numerous inquiries in the market for shipment lots of considerable tonnage. Many of the foreign markets are just thirsting for steel material, and with their need being so urgent the present high prices matter less than the securing the promise of an early delivery, but this is just what makers do not feel inclined to do just yet, with the result that the export trade continues very small.

Malleable Iron Trade.—The malleable iron works are all very busily employed at the moment, and a large output is general. Naturally the bulk of the work is on home account and only a small tonnage is being exported, as order books are filled up well ahead with local demands. Prices are very strong, and once again deliveries count more than values.

Scotch Pig-Iron Trade.—Active conditions continue in the Scotch pig-iron industry, and a good general demand is being experienced. The latter is mainly for local need, but shipment lots are receiving some attention and improvement in that direction is noticeable, even though it be slow. The removal of the necessity of securing an export licence has tended towards more dealing. No. 1 iron is still a bit scarce, but delivery of small lots can be given fairly promptly, and forge iron is a little more plentiful. The demand for hematite is good and deliveries to the steel works are very satisfactory. Prices all round are very firm, and the tendency is of an upward nature.

Steel Trade Bricklayers' Wages.—In connection with the recent dispute between the steel works bricklayers and the Scotch steelmakers over wages, another phase was reached yesterday, when Sheriff Shennan presided over the Arbitration Court in Glasgow. Representatives were present from the Scotch steel manufacturers and the bricklayers' union. The decision of the Court will be intimated later. It is interesting to note that the present rate of wages is 1s. 10½d. per hour, and if the original demand of 9d. per hour should be granted the minimum weekly rate would amount to 5l. 16s.

THE SOCIETY OF ENGINEERS (INCORPORATED).—The Council of the Society of Engineers, at the annual general meeting on December 8, awarded the following premiums for papers presented during the year: (1) President's gold medal to Mr. Alfred S. E. Ackermann, for his paper on "Experiments with Clay in its Relation to Piles"; (2) Bessemer premium, value 5l. 5s., to Mr. C. O. Bannister, for his paper on "Heat Treatment of Steel"; (3) Nursey premium, value 3l. 3s., to Professor J. Young, for his paper on "Modern Explosives"; (4) A society's premium, value 2l. 2s., to Captain de Jarny, for his paper on "Development of Artillery during the War."

NON-FERROUS METALS.—The following particulars are published of the stocks (exclusive of old metal and scrap) in this country in possession of the Minister of Munitions on December 1, 1919:—

	Tons.
Copper	14,867
Spelter (G.O.B.)	12,848
Spelter (refined)	10,940
Aluminium	8,911
Soft pig lead	59,912
Nickel	1,800
Antimony regulus	2,950

A proportion of the above stocks is already sold to the trade for forward delivery.

NOTICES OF MEETINGS.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, December 13, at 6.30 p.m., at the Education Offices, St. James'-road, Dudley, the third meeting of the session will be held, when Mr. L. C. Harvey (of London), will read a paper on "Pulverised Fuel."

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, December 13, at 2 p.m., General Meeting in Wood Memorial Hall, Newcastle-on-Tyne. The following papers will be open for discussion: "The Difficulties and Dangers of Mine-Rescue Work on the Western Front; and Mining Operations carried out by Men Wearing Rescue-Apparatus." By Lieutenant-Colonel D. Dale Logan [Trans. Inst. M.E., vol. lvii, page 197]; "Accidents Due to Structural Defects of Apparatus or Injury to Apparatus; and the Future of the Proto Apparatus," By Lieutenant-Colonel D. Dale Logan [Trans. Inst. M.E., vol. lvii, page 223].

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, December 13, at 7 p.m., Quarterly Meeting, at the Grant Hotel, Aytoun-street. To give formal notice, on behalf of the council, that at the next Annual General Meeting, the following new rule will be submitted for consideration: "That any member, over 65 years of age, who has retired from business and who has been a member continuously for over 25 years, and whose subscriptions are not in arrear, if unable for financial reasons to continue his membership may make a declaration to this effect to the council, and apply to have his future subscriptions reduced or remitted, without prejudice to any rights he may have under the rules of the association, and the council may, at their discretion after due investigation, reduce or remit further subscriptions." The undermentioned paper will be read and discussed: "Scientific Management," by Mr. H. W. Allingham, M.I.Mech.E.

THE SURVEYORS' INSTITUTION.—Monday, December 15, at 8 p.m. A discussion will take place on the subject-matter of the recent Opening Address of the president, Mr. Andrew Young, which dealt with the future policy of the Institution on the completion of its jubilee.

THE ROYAL SOCIETY OF ARTS.—Monday, December 15, at 8 p.m.: Cantor Lecture, "Synthetic Drugs," by Mr. John Theodore Hewitt, M.A., D.Sc., F.R.S., Emeritus Professor of Chemistry, East London College University of London (Lecture III). Wednesday, December 17, at 4.30 p.m.: Ordinary Meeting, "The Present Economic Position of Russia and Some Aspects of its Future Development," by Mr. Constantine Grunwald, late Chief of Intelligence Department, Russian Ministry of Trade and Industry. Thursday, December 18, at 4.30 p.m.: Indian Section, "Some Problems of Indian Education," by Mr. P. J. Hartog, C.I.E., M.A., Member of the Calcutta University Commission, 1917–19. The Right Hon. Lord Meston, K.C.S.I., LL.D., will preside.

THE FARADAY SOCIETY.—Monday, December 15, at 7.50 p.m., Annual General Meeting in the Rooms of the Chemical Society, Burlington House, Piccadilly, London, W. 1. An Ordinary Meeting will subsequently be held at 8 p.m. The following papers will be presented: "Electrolytic Iron Deposition," by Lieutenant W. A. Macfadyen, M.C., B.A.; "The Measurement of Physical Properties at High Temperatures," by Mr. A. George Tarrant, B.Sc., A.R.S.C.; "The Electrolytic Formation of Perchlorate from Chlorate," by Mr. J. Guilfoyle Williams, B.Sc., A.I.C.; "On the Vapour Pressures of Binary Mixtures," by Professor Alfred W. Porter, D.Sc., F.R.S.; "Some Relations between the Solubilities of Solutes and their Molecular Volumes," by Mr. Shinkichi Horiba; "An Accurate Method for the Determination of Vapour Pressure," "Some Properties of Copper Ferrocyanide," by Mr. E. J. Hartung, D.Sc.; "The Solution Theory of Steel and the Influence of Changes in Carbide Concentration on the Electrical Resistivity," by Professor E. D. Campbell.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, December 16, at 5.30 p.m., at the House of the Royal Society of Arts, John-street, Adelphi, W.C. 2. The following paper will be read: "The Application of Liquid Fuel to Heavy-Oil Engines," by Mr. A. J. Wilson, A.M.I.M.E.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, December 16, at 8 p.m., Meeting at the House of the Royal Society of Arts, John-street, Adelphi, London, when a Lecture on "The Art of Camouflage," illustrated by lantern slides, will be delivered by Captain W. A. Howells (of the R.E. Camouflage School, Larkhill).

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 16, Meeting at 5.30 p.m. Paper to be submitted for discussion: "Precise Levelling," by Major Ernst Olaf Henrici, R.E., Assoc.Inst.C.E.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, December 16, at 6.30 p.m. Adjourned discussion, Subject: "A New Form of Ship's Keel to provide a Clear Passage Fore and Aft," by Mr. E. F. Spanner, Member.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, December 17, at 5 p.m., Meeting at 70, Victoria-street, Westminster. Papers to be read: (1) "The Laws of Approach to the Geostrophic Wind," by Mr. F. J. W. Whipple, M.A., F.R.Met.Soc.; (2) "Winds and Temperature Gradients in the Stratosphere," by Mr. G. M. B. Dobson, M.A., F.R.Met.Soc.; (3) "Quotations from the Diary of Samuel Pepys on the Weather," by Captain C. J. P. Cave, F.R.Met.Soc.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, December 17, at 8 p.m., Meeting at Colquitt-street, Liverpool, when a paper will be read by Mr. H. T. Newbigin, Assoc.M.Inst.C.E., entitled "The Science and Art of Lubrication."

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, December 17, at 2 p.m., in the Institute of Chemistry, 30, Russell-square, London, W.C. 1. The subject will be: "The Position of the Glass Industry in America," and the speakers, Mr. J. Connolly, Dr. M. W. Travers, F.R.S., and Dr. W. E. S. Turner, who have recently visited the States.

THE INSTITUTION OF ELECTRICAL ENGINEERS: WIRELESS SECTIONAL MEETING.—Wednesday, December 17, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Professor G. W. O. Howe, D.Sc., "High Frequency Resistance of Wires and Coils."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 18, Ordinary Meeting at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Paper to be read: "Electricity in Tin Mining," by Messrs. D. M. W. Hutchison and W. J. Wayte.

THE CONCRETE INSTITUTE.—Thursday December 18, at 7.30 p.m., Ordinary General Meeting in the Lecture Hall at Denison House, Vauxhall Bridge-road, by Mr. M. S. R. Adams on "The Use of Elliptical Vaulting as a Primary Factor in Contemporary Architecture" (lantern).

THE INSTITUTION OF BRITISH FOUNDRYMEN, LONDON BRANCH.—Thursday, December 18, at 8 p.m., Meeting at the Cannon-street Hotel. Mr. A. R. Bartlett, of Messrs. Fraser and Chalmers, Erith, will read a paper, illustrated by lantern slides, on "Plate Moulding, Pattern Plates and Machine Moulding."

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, December 18, at 5.30 p.m., Ordinary General Meeting at the Rooms of the Geological Society, Burlington House, Piccadilly, London. The discussion of the following paper, a copy of which was issued with the last Bulletin, will be resumed: "A Contribution to the Study of Flotation," by Mr. H. Livingstone Sulman, Member.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 19, at 6 p.m., General Meeting at the Institution, Storey's Gate, St. James's Park, S.W. Paper to be read on "Cutting Power of Lathe-Turning Tools" (Part II), (being an account of further experiments made in the machine-tool laboratory of the University of Sheffield), by Mr. G. W. Burley, Wh.Ex. of the University of Sheffield, Associate Member.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, December 19, Meeting at Royal United Service Institution, Whitehall, W. 1. Presidential Address, "The Influence of the War on Engineering," by Sir E. Tennyson d'Eyncourt, K.C.B., M.I.N.A. The chair will be taken at 7.30 p.m. by Sir Henry J. Oram, K.C.B.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Coal Market.—Actual business is quiet and principally confined to parcels for shipment before the Christmas holidays. Available supplies of coal of all grades are scarce, as collieries generally are fully stemmed and well supplied with shipping. Slow loading operations at the docks and delay in the return of empty wagons to the pits, however, cause considerable inconvenience, and it is not exceptional to find collieries on stop because of an insufficient supply of empties, despite the fact of a full stem list, with as many as a dozen vessels actually in dock waiting cargoes. The reason for this is that the tipping accommodation is not adequate to cope with the requirements of exporters and consequent delay in loading. Prices in the circumstances are very irregular and entirely dependent on individual circumstances. Thus for shipment, say, a week or more off, sellers firmly indicate up to 92s. 6d. for the better quality large coals and 72s. 6d. for the best steam smalls. On the other hand, buyers with boats actually under the tips, or able to guarantee quick loading, can secure supplies at anything from 80s. up for good class large, and 65s. for best smalls. Exports last week totalled 352,716 tons, of which 162,674 tons went to France, 80,112 tons to Italy, 50,254 tons to South America, 10,034 tons to Spain, 13,408 tons to Portugal, 25,337 tons to British coaling depots and 10,897 tons to other countries.

Iron and Steel Trades.—There is a good foreign inquiry for tin plates, and prices remain firm. It is believed that foreign buyers have been speculating as merchants have received orders to defer or divert quantities already sold, and it is thought that the reason for this is that a fair amount of re-selling has taken place. It is not anticipated that this will have any effect on the local market as makers are well booked with contracts ahead. Up to 47s. has been paid for the basis box, though prices generally are round 46s. 6d. Inquiries are in circulation for April-July delivery at 46s. per box f.o.b. Galvanised sheets are strong up to 41l. for 24-gauge corrugated for March-April shipment, but it is difficult to place orders. Tin and sheet bars are firm at 16l. 10s., but business is restricted by transport difficulties.

Newport Fuel Works.—Mr. W. H. Renwick, Cardiff, managing director of the Pacific Patent Fuel Works, Swansea, has acquired a controlling interest in the Cardiff and Newport Patent Fuel Company, which manufactures the "Arrow" brand of fuel, of which a large quantity was supplied to the French railways during the war. The output of the Newport works is about 150,000 tons per annum.

CONVEYOR INSTALLATION AT THE MAYPOLE MARGARINE FACTORY, SOUTHALL.

CONSTRUCTED BY MESSRS. W. AND C. PANTIN, ENGINEERS, LONDON.

(*For Description, see Page* 781.)

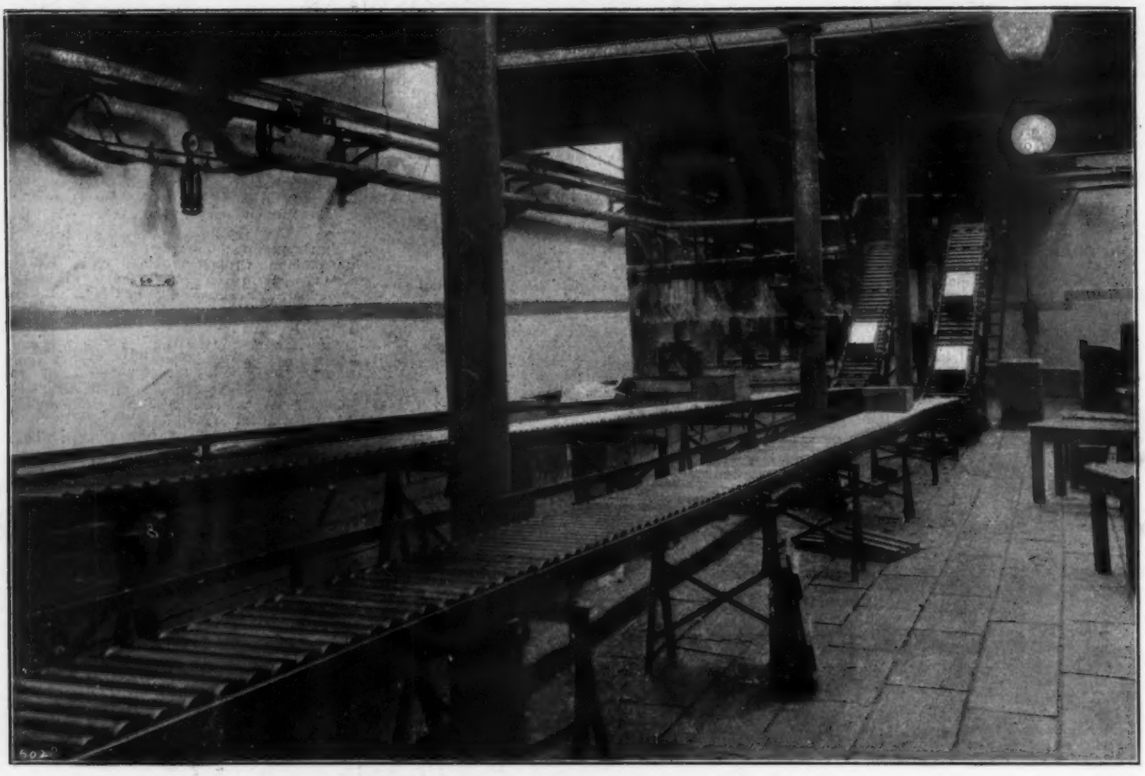


Fig. 24. No. 1 Elevators approaching the Nailing Room.

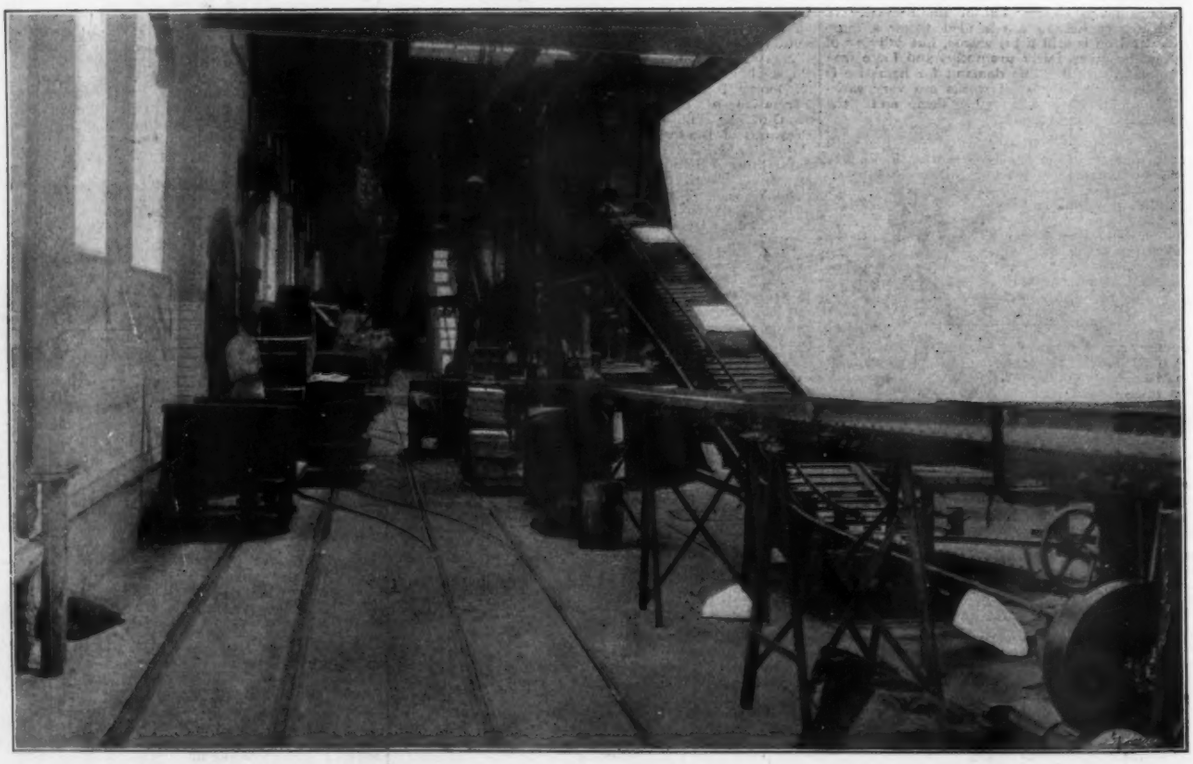


Fig. 25. No. 2 Elevator, Nailing Room.

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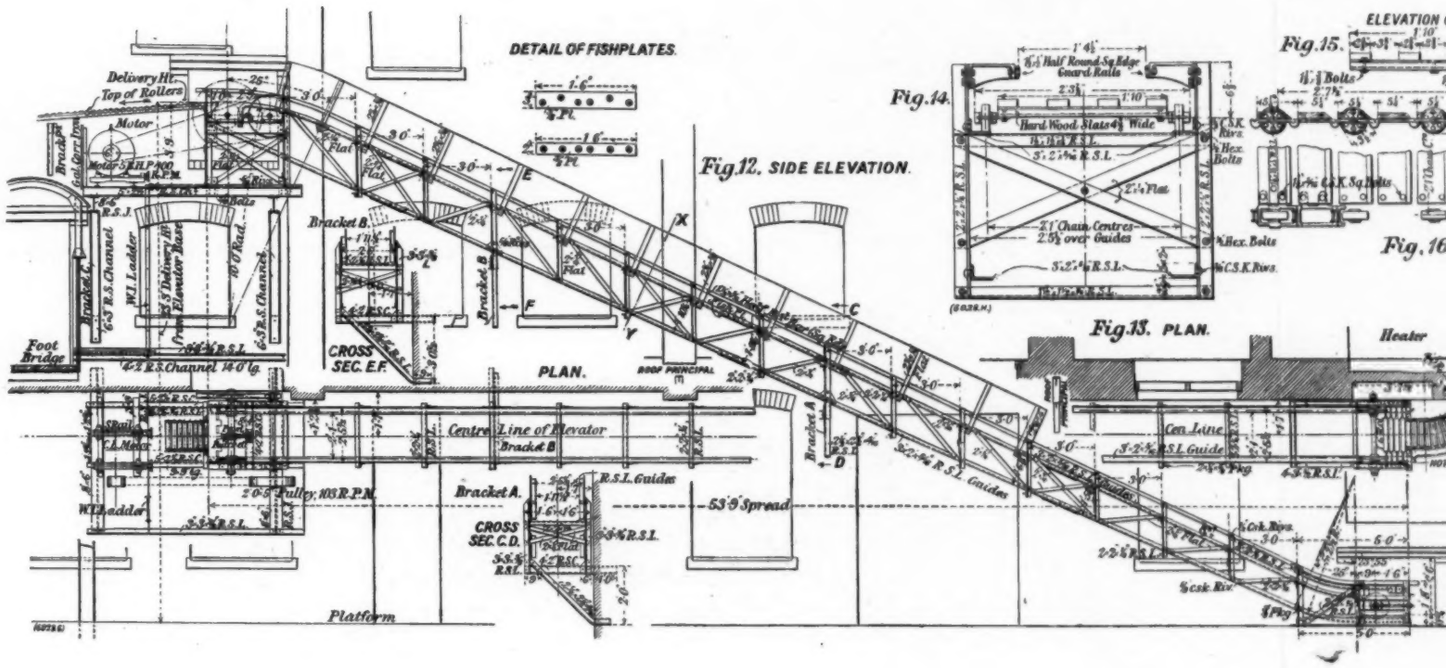

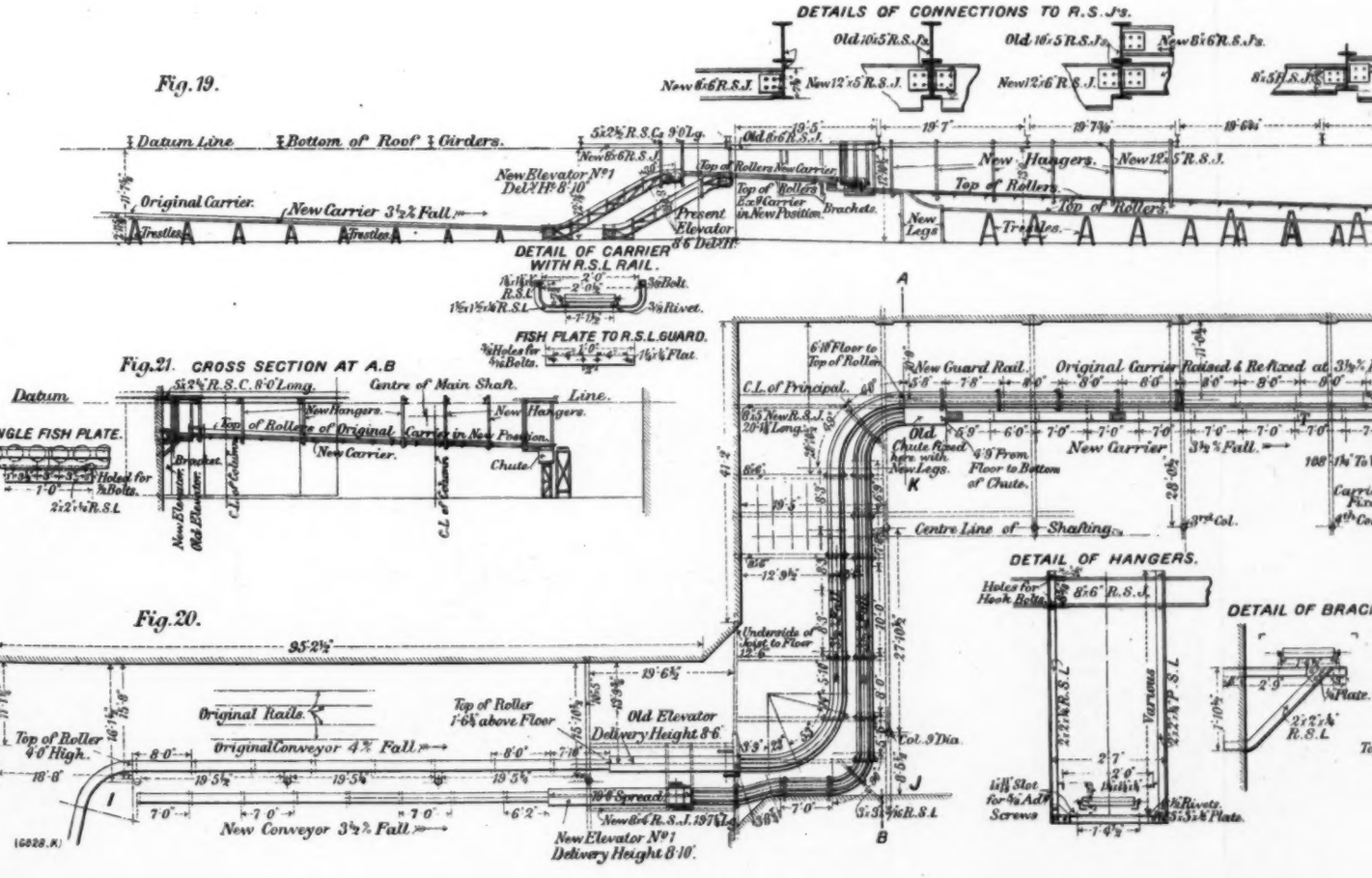

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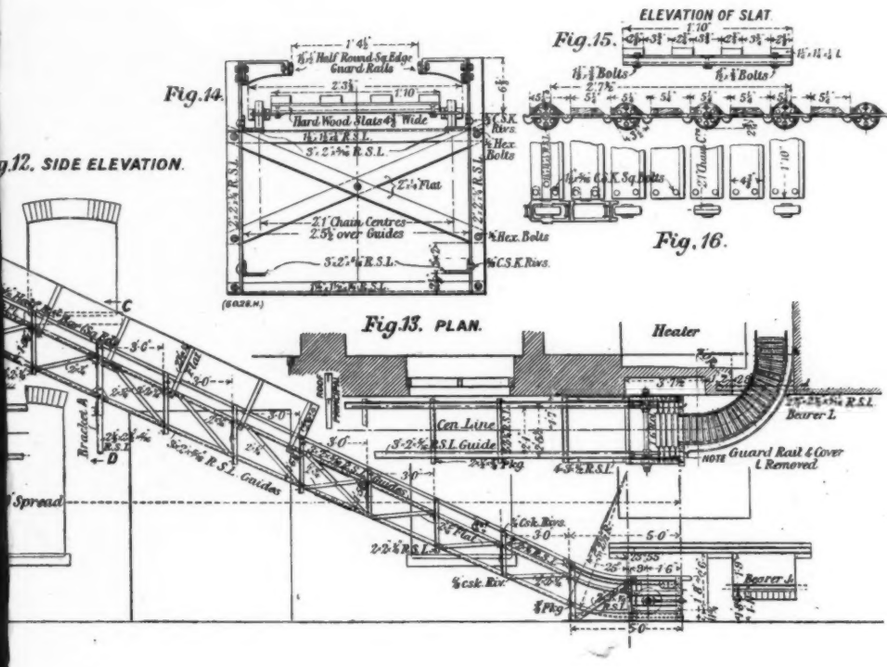

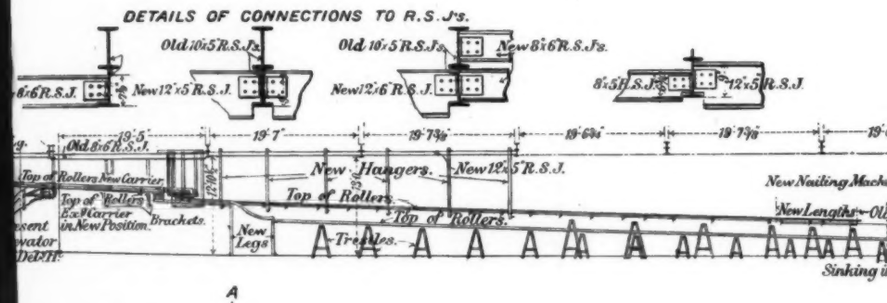

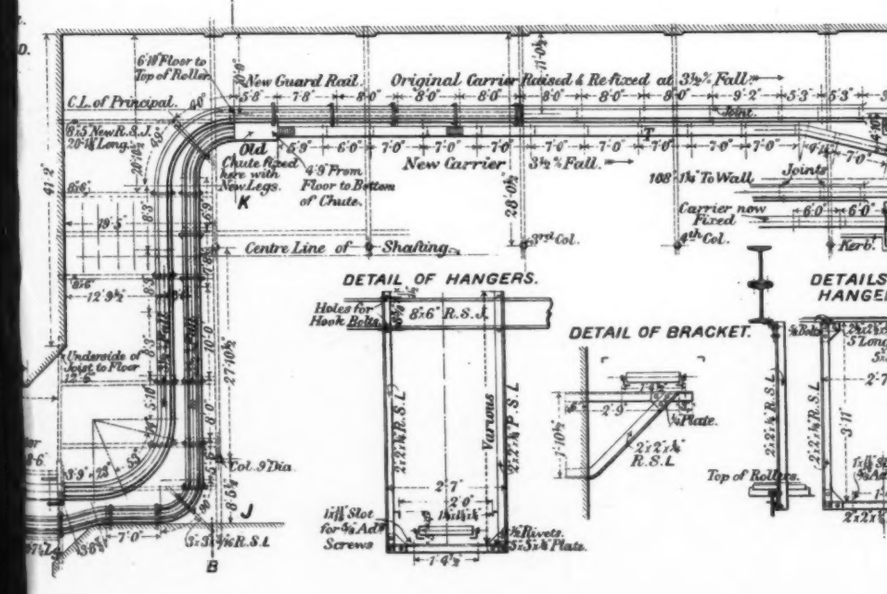

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TIN, ENGINEERS, LONDON.

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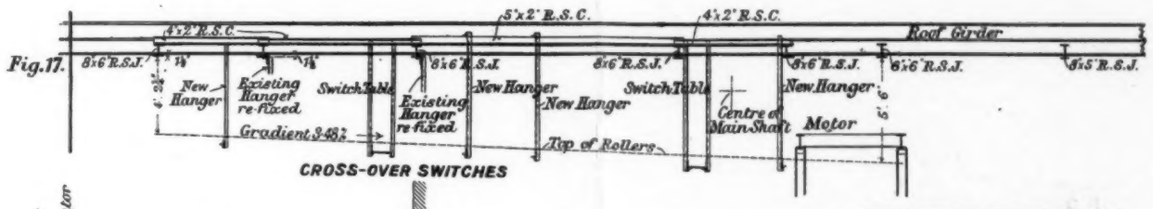
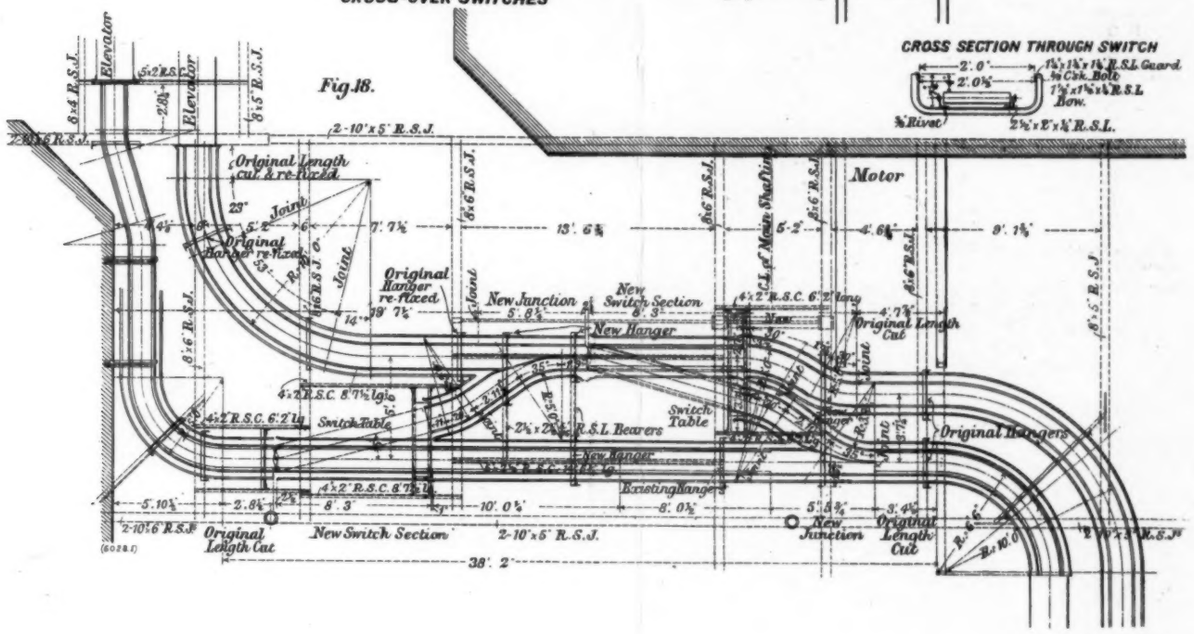
Fig.17.



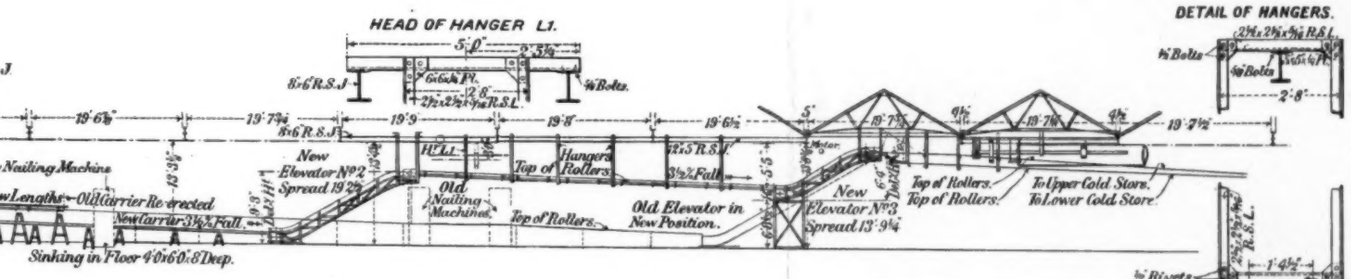
CROSS-OVER SWITCHES

Fig.18.

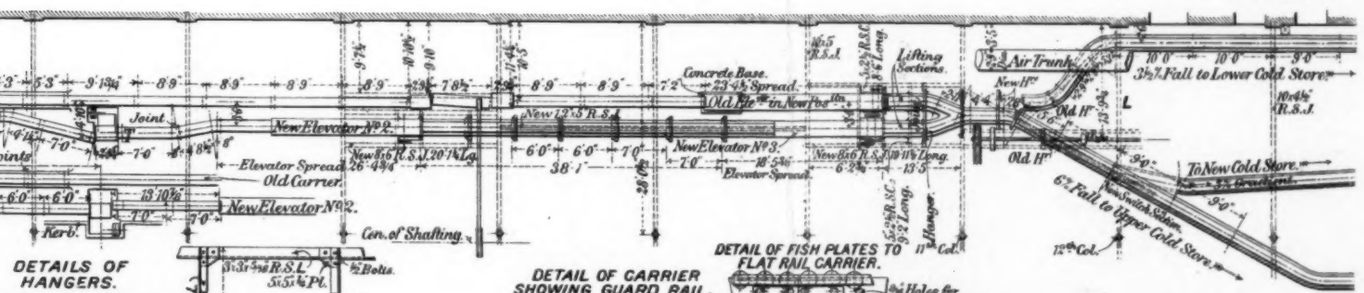


CROSS SECTION THROUGH SWITCH

HEAD OF HANGER L1.



DETAIL OF HANGERS.



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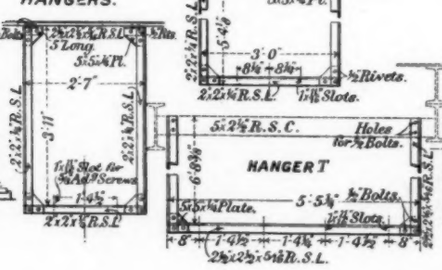
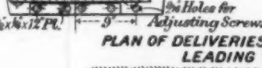


DETAIL OF CARRIER SHOWING GUARD RAIL.

DETAIL OF FISH PLATES TO FLAT RAIL CARRIER.



PLAN OF DELIVERIES FROM ELEVATORS TO ROLLER CONVEYOR LEADING TO THE LOWER COLD STORE.

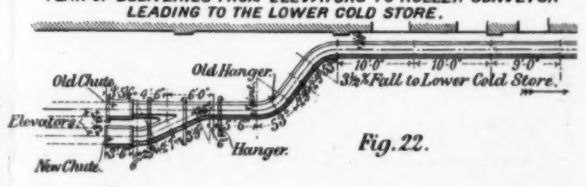


Fig.22.

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TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue.
For Advertisements, J. S. Allan, 18, Broadway, New York.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

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For Canada—	
Thin paper copies	£2 18 6
Thick " "	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
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When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

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TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON,

TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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NOTICE.

Owing to the enormous increases in the cost of paper, engravings, and printing charges generally, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 9d. to 1s. per copy. This increase will date from and include the issue of Friday, January 2, 1920. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

CHRISTMAS HOLIDAYS.

Owing to Christmas Day this year, falling on Thursday, it is necessary that our issue of the 26th inst. should be published on Wednesday, the 24th inst., and, in consequence, all alterations to standing advertisements should be received not later than Wednesday, the 17th inst. Advertisements to appear classified under the various headings such as "Tenders," "Appointments Open," "For Sale," &c., must be received by the first post on Monday, the 22nd inst.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 789.

ENGINEERING.

FRIDAY, DECEMBER 12, 1919.

GOOD ROADS.

THE subject of good roads, though not as old as the hills, at least dates back to the earliest civilisations. Even the old Hebrew seers realised their advantages. Isaiah, a man of learning and position at court, must, one would think, have sometime been a road engineer, perhaps on the then Road Board, or in the Ministry of Transport, for his utterances on the subject are frequent. In his visions of a future time of happiness and prosperity good roads were an essential feature. How he would have rejoiced to see realised "in the desert a highway" as built by our Palestine Force, or the consummation of free intercourse he longed for when he foretold "in that day there shall be a highway out of Egypt to Assyria." Did he foresee our Class I and II roads when he prophesied "a highway shall be there and a way," or was this an anticipation of separate roads for fast and slow traffic? His economics were sound. His ideal highway was straight, in which "every valley shall be exalted and every mountain shall be made low: the crooked shall be made straight, and the rough places plain." Had he been addressing a modern meeting he could scarcely have chosen better when promising well-drained roads in the bottoms, easy grades to the lorry user, or arterial roads and smooth surfaces to the motorist. His call to work is as keen as that of any enthusiast of to-day: "Cast up, cast up the highway; gather out the stones!"

Isaiah's mind seems to have focussed rather on the roads than on the speed of future traffic, but whoever has watched modern military transport will realise how aptly, had they referred to delivering forces, the words of Jeremiah might have been applied to the movements of our Palestine and Mesopotamian expeditions: "He shall come up as clouds, and his chariots shall be as the whirlwind." Nahum, too, has a vivid picture: "Chariots shall rage in the streets; they shall jostle one against another in the broadways, they shall seem like torches, they shall run like the lightnings." Could there be a better description of the noises of mechanical traffic, of the glaring head lamps, and of the high speeds and congestion which have resulted in the demand for speed-ways and street widenings. Would these old-time worthies after all have been much out of place at the recent Road and Transport Congress?

That we are lamentably behindhand with our roads is agreed. Though they saved the country in the railway strike they would have undoubtedly broken down completely had that emergency traffic continued. Before 1914 the revision of our standards of construction had received a good deal of practical attention. Then came the lean years; work had to be curtailed. Engineers and men went overseas—materials were unprocurable. We built military roads in all quarters of the earth, under all conditions, of all materials. While roads here grew worse from neglect and heavy military traffic, mechanical transport was coming into its own. Never before had there been such an opportunity of testing it on such a scale. Rapid developments followed. We now realise as never before that road transport will take its place alongside railways in our daily life. It will successfully compete for much traffic, especially when the railways raise their rates, as they must on the withdrawal of the subsidy.

Our drivers have had such experiences during the war that they would probably run over far rougher roads than our worst. A first-class service of national value, however, which can promise convenience, reliability and cheapness to its patrons, can only be built up by bringing the two factors of roads and vehicles into harmony, just as in a well-found railway the rolling-stock and permanent-way are proportioned to one another. A low standard of either will not serve. Were both, as in a railway, in the same hands, we may be sure that developments of either would be made to keep pace with the progress of the other. Further, under these conditions, if an economic development of the one occurred money would almost certainly be assured to bring the other into consonance with it. So we come to the necessity for finding the money necessary to put our roads into a fit state to stand up to modern traffic, in order that road transport may become an asset in our national economy. All the money must come ultimately from the public, but there are two points concerning its fair distribution which are worth bearing in mind. Any tax on industrial vehicles run by contractors will be passed on to the party hiring the transport. Thus the beneficiary would rightly contribute. Such a tax, therefore, has distinct advantages. On the subject of raising the necessary money by rates it must be borne in mind that much of the heavy through traffic requiring first-class roads brings no benefit at all to property owners in intermediate districts. For this reason one levy for the whole country would probably work out more fairly than levies in the form of local rates. As, however, there is no prospect in these days of the national contribution being made at all proportionate to the work to be done, in view of other demands upon the Exchequer, some compromise between the two appears desirable. It was suggested by Mr. Rees Jeffreys that this should take the form of levies by Regional authorities. The respective spheres of these authorities would be delineated, we take it, purely according to traffic requirements and problems, and would not necessarily bear any relation to county or district boundaries. They would each be large enough to treat road schemes on a comprehensive scale and to spread the levies fairly over a considerable area comprising both populous and rural districts. Some such system is necessary to give relief to the rural districts and to prevent them often being, as they are now, the unfortunate cause of obstruction to larger schemes.

We are told that at least 200,000,000*l.* spread over five years will be necessary to cover the cost of bringing up our existing roads to a reasonable modern standard. This is required for maintenance, necessary improvements and reconstruction of the surface, and would not include new roads, bridges, and widenings, or similar projects to the western approach road to London. Though several relief roads are in hand, we probably have with work on our existing roads enough to do to occupy all our energy and to absorb all the procurable money and material for some years to come. But, if the opportunity occurs, let us be farsighted enough to reserve land for future arteries.

Supposing we get these large sums, it must be admitted that many of our local authorities such as the smaller rural district councils, are not properly situated for undertaking the class and quantity of work required by our main roads. They have not the command of first-class technical staff with wide knowledge and experience, nor could they afford it. It has been rather amusingly suggested by Mr. Rees Jeffreys that the salary of a local

authority's road engineer should be a gauge of its fitness to act as a highway authority. Though it has a touch of levity there is actually a good deal in the proposal, for a sound technical staff and organisation are essential. If regional road authorities are set up it would seem more or less logical, in order to secure a suitable uniformity of standard within the region, to give them the staff required to control or conduct the work. The county staffs, while competent, could not very well work for regional road authorities owing to the difference in areas. The regional system has the advantage for the work of reconstruction that programmes could be arranged largely independent of local bodies. The regional authority would have larger resources at its command as regards expert staff, machinery and local material. To ensure economy we must carry out the work on a big scale. Only in this way can the machinery and methods adopted in America be introduced to lower our costs here. A 20-mile stretch is no uncommon length of road to take in hand there at a time, and for this light railways and a great deal of plant is collected and the organisation brought to a very high pitch. If its own contractor, a large authority is in a position to provide the best staff and modern machinery, while if it employs a contractor it can place large orders. The cost of materials and labour having risen, machinery will be essential. It cannot be provided either by small bodies themselves, or in connection with their small contracts.

On practical points the recent conference was not definite. The advocates of concrete and of asphalt roads show no signs of any *rapprochement*. Neither form of road is ideal. The time required for setting, at an economical rate of laying the concrete, means that immense lengths of such roads must be out of use for a month. This is impossible in this country, as no alternative roads exist and whole tracts of country and often villages would be isolated. A small repair patch also may form an obstruction to traffic for 28 days, during which time it has to be fenced and lighted, and is a constant expense. On the subject of reinforcing, Mr. Max Clark pertinently pointed out that subsequent trenching ruined the reinforcement for good and all. The endeavour was made to make a case out for the examination of all mains, &c., prior to laying such a road. These roads are claimed to last twenty-five years and who shall say, when changes come so thick upon us, that any examination now would obviate trenching in that time?

The asphalt road or what Colonel Crompton prefers to call the bituminous carpet type of road remains. Is this to be our Magic Carpet of the future? It certainly is the surface for speedways if they ever come. But this again has its disadvantages. There is undoubtedly something in the complaints of slipperiness levied against it. The concrete people are one up on this. Can anything be done to improve the surface? Mr. Collins, of Norwich, suggested mixing broken brick with the top asphalt coat, to encourage slight differences in wear. It may be that the advocates of these modern systems are unwise in claiming practically no wear. A grinding wheel which is too hard or is run too fast glazes; it does not wear enough to expose the fresh sharp abrasive. A small amount of uneven wear, not of course in this case of the matrix with the object of exposing abrasive matter as in the grinding wheel, but rather to expose a slightly roughened resilient matrix, may prove ultimately to be better than the unwearable road surface, which soon becomes like glass. Town dwellers, as most engineers are, are rather too apt to forget the interests of their fellow men whose livelihood requires their occupation of country districts, and the employment of other means of transport than the motor. We are pleased to see that a committee has now been appointed to investigate this matter, by the County Surveyors' Society at the request of the Ministry of Transport. This committee will have authority to carry out experimental work, and is prepared to receive practical suggestions, which should be addressed to the Chief Engineer, Ministry of Transport (Roads), Whitehall Gardens, S.W. 1. The horse certainly needs full consideration. It will be useful to us for a long time yet.

WORKERS' OBJECTIONS TO SYSTEMS OF PAYMENT BY RESULTS.

THE attitude taken up within the last few months by certain of the great trade unions in this country, in rigidly opposing all systems of payment by results, and their demands, under threat of strikes, to revert back to plain time work, raises afresh the question as to the exact nature of the objections to such systems. During the war, remuneration in proportion to measured output was fostered by the authorities virtually controlling industry, and under the pressure of circumstances was continuously urged upon employers and employed. The response was a considerable extension in application and scope. In spite of the higher earnings always accruing from this innovation, the present demand in certain quarters is, now peace is declared, to revert to plain time work. Workers are often swayed by their union officials to take up a stronger collective attitude than their individual inclination may dictate. In dealing with the opposition to payment by results, it may be stated that, whilst individually the workers concerned can rarely even define their objections, much less discuss them, yet it is apparent that the feelings on this subject are deep rooted and, in consequence, merit attention.

The strongest objections generally spring from the more intelligent classes of labour. The results of improved education are being more generally felt and bring, as must all such progress, the disadvantages of ill-assimilated knowledge and the dangers of incomplete understanding of economic conditions. A very considerable number of skilled workers at the present time are opposed to systems of payment by results. It would almost seem that the amount of the opposition is in direct proportion to the skill of the trade.

In this country, further, where the trade union movement is in a much more highly developed state than in any other, these objections are not only strongly held, but, in consequence of this development, are capable of being expressed with an organised voice. In those countries where trades unionism is gaining ground a similar state is no doubt in process of formation. In countries where labour organisation is undeveloped, piecework is quite general. It is not unlikely that, in such cases, the same process will be gone through as has and is the case here. In Britain, with the lesser-skilled workers, and also in the great trades such as the cotton, boot-making and coal-mining industries, work is almost exclusively carried out on piecework, generally according to list prices mutually agreed upon between the employers and the employed.

Systems of payment by results mean increased production. Frequently and repeatedly it is stated that the object of the resistance on the part of the workers, and the tendency and the inducement to "ca' canny" or restrict output, is to cause a greater number of workers to be required and employed to undertake a given amount of work. Against this can be cited the economic truth that the cheaper the product the larger the market, and, consequently, the greater the demand for workers. That payment by results cheapens production is admitted by all. To leave the matter thus—and there is perhaps too great a tendency so to do—means a deadlock. In this vital matter of the remuneration of labour, reasonably harmonious relationship between Labour and Capital is agreed to be one of the first essentials of the present serious times, however difficult may be the attainment. Our industrial future otherwise will be clouded by grave uncertainties.

If a belief is so strongly held, as is this objection on the part of the men to payment by results, one of two points will be conceded—either that ignorance is so prevalent and truth gains ground so slowly that our industrial future might well be despaired of, or there is some truth in the workers' attitude, to be revealed perhaps by regarding their position, which on direct analysis seems so fallacious, from different angles in order, if possible, to discover the underlying causes.

The question of the unemployed is concerning many minds at the present time, and is truly a vital one. How is it affected by payment by results? The following example illustrates actual occurrences and the effect upon the point of view of the men directly concerned will be obvious. When payment by results is applied to a shop working on plain time rates, the output is speeded up and more work is accomplished. The shop and production records consequent upon working on such a system show that there are more men in the shop than there is work to justify. Employees, in consequence, are paid off. Two reasons may be noted—firstly, output is accelerated and, unless foresight has been exercised, men will be out of work until such time as the demand created by the reduced selling price arising from the improved condition of production sets in; secondly, records of work accomplished are kept probably for the first time. The net result, however, is the paying off of men, and an unemployed man will be little inclined to take a long view or to find consolation in a contemplation of the increased earnings of those remaining in employment. It is a fundamental consideration that, before payment by results is mentioned, the shop and the work should be thoroughly organised, careful records kept, and there must be full assurance that there is adequate work ahead to ensure employment to all the workers. Ample allowance requires to be made when computing future performance, to the augmented output certain to accrue from the extra incentive of higher wages towards greater effort. In such a way one of the strongest arguments against systems of payment by results will at least cease to be emphasised by actual happenings in such a direct and forcible way as has so often been the case.

The subject of unemployment generally is too large for treatment under the heading of this article, although the fear thereof is real. It need not be supposed, as is sometimes the case, that the more intelligent workers do not appreciate that full employment follows from increased production and a state of national prosperity. To a certain extent the extreme Socialistic section of the malcontents have their influence on the masses, and in part the resistance to the adoption of remuneration according to output is stimulated with a view to protest against the present distribution of the wealth accruing from increased production, which is held to be unfair to the manual worker and out of proportion to his efforts towards its creation. Largely this attitude is simply the outcome of ignorance, and at the present time (neglecting war conditions), in the engineering industries in particular, it is probable that the opposite is true, and that the manual workers are receiving more, if anything, than their due. That the distribution of the earnings of industry amongst the various trades is not in proportion to their skill is probably the case, but does not arise under this heading.

Collective systems of remuneration are not subject to the same opposition as individual systems. In some quarters even the collective system or collective contract under certain conditions of operations is actually urged upon the workers by certain Socialistic organisations, as giving to them more power than hitherto in assessing their own wages and determining the conditions of work. The difficulties of operation and the objections to such systems have been already dealt with in ENGINEERING (see vol. cvii, page 85), under the title "Collective Systems of Payment by Results."

It is the individual systems that engender the most resistance. Trades unionism has been built upon the foundation of collective bargaining, and in this country to-day the principle is generally conceded. The individual system except when a mutually agreed upon price list operates, entails dealing with individuals or small groups of individuals. Competition and jealousy between individuals is a possible outcome, as, for instance, where there are two workers on the same type of work, one who makes it pay handsomely and the other who runs the job into debt, not having the adaptability, perhaps, to this particular class of work. Such cases advertised by unsuccessful workers may form centres of discontent. If the system is well administered, such incidents will be so handled as to minimise any bad feeling.

A number of skilled workers aver that the ten-

dency to scamp work, in order to increase production and earnings is fostered by payment by results, and that the deterioration in quality of product more than counterbalances the gain from the speeding up. Such a tendency is undoubtedly present. It is however, counteracted by improving the supervision and inspection departments, and this should be done, if necessary, before the system is inaugurated.

Competition is a strong stimulant, but there are limits beyond which it may be harmful. In industries this is recognised by the trading arrangements which are made with a view to restricting undue competition.

Furthermore, of the individual systems, the various bonus systems are much less popular than piece work. The workers do not understand why they should not be credited with the whole of the time saved, instead of with the 33 per cent., 50 per cent., 66 per cent., or as the case may be, according to the particular system in operation. They do not realise that it is of relatively little importance which of the various individual systems are adopted. The manner in which the system is administered is the all-important factor. If the estimates of prices or times are meagre, then little pecuniary gain will result whichever system be adopted, and conversely. Any questions having an influence upon wages require careful and experienced administration. Several pit-falls have been indicated. All considerations of payment by results inevitably come back to the setting of the basis time or the piece price. Upon this factor many of the difficulties centre. Increased experience, improving administration, and above all, accurate rate setting on a scientific basis must be relied upon gradually to raise the question of payment by results in the workers' minds from the present shadow of suspicion engendering opposition, to a firmer footing of confidence tending towards maximum production and high earnings.

AN EXPERT ON INDUSTRY.

IT is a serious misfortune that engineers who play such a prominent part in the creation of wealth are far from successful in impressing on the public their views as to industrial and economical conditions. The proceedings of our technical societies are for the most part ignored by our daily journals and monthly reviews, whilst great deference is paid to the views of men far less competent on such matters. In the House of Lords on Tuesday last, for example, Viscount Haldane made the grotesque misstatement that "we had never really thought out the electricity question in this country, but left it to private enterprise." This inaccuracy will probably be repeated in hundreds of daily journals; whilst the true statement of the case, as given by Mr. J. C. Sparks in his presidential address to the Institution of Electrical Engineers in 1915, was, to put it mildly, exceedingly inadequately reported. No competent authority will deny that had the electricity question been left to private enterprise here, as Lord Haldane suggests was the case, we should have had splendid systems of electrical power distribution all over the country, and the need for the Electricity Supply Bill now under discussion would never have arisen, and the nation would have been richer by scores of millions per annum.

It is to be feared that the interesting and thoughtful address of Lord Weir to the Institution of Marine Engineers, delivered on December 2 last, is little more likely to attract the attention of the daily press than did the pronouncement of Mr. Sparks four years ago. In this address Lord Weir brought the special experience of the engineer to bear upon a number of important industrial questions now pending. The engineer and the "Fabian" approach such questions as the nationalisation of an industry from opposite standpoints. The Fabian asks—What is plausible, not what does experience show to have happened in the past.

A characteristic instance of this unscientific attitude of mind was quoted by Lord Weir from Mr. Sidney Webb's evidence given before the Coal Commission, evidence, which it may be added, would probably never have been tendered had not the witness been well assured that he was safe from effective cross-examination. The quotation is:—

"If the miners are assured that improved processes would deprive no man of regular employment at the standard rate it is difficult not to believe that a Government Coal Department could in a few years revolutionise the processes of the backward half of the collieries." Lord Weir pointed out that Mr. Sidney Webb would thus control the rate and extent of the application of new processes by the state of employment. If, for example, a new system of transmitting energy particularly applicable to coal cutting were devised, making the present output possible with half the number of men, then, as Lord Weir points out on Mr. Webb's thesis, the new process should be banned. There is, however, another objection perhaps still more fundamental to the doctrine criticised. It will be seen that Mr. Webb was extremely careful in his phraseology. No doubt it is possible to conceive that a Government Department could revolutionise the industry by the adoption of improved processes. But the scientific engineers is not concerned with what is conceivable but with what is probable. Is there, in fact, any reason for believing, in view of the past record of Government Departments, that the benefits in question would be actually realised. An eminent American engineer has stated that until the telegraphs were taken over by the Crown, three-fourths of the improvements effected in telegraphy originated in this country. Subsequently the improvements we adopted were almost wholly imported, as the Government control had the effect of closing almost completely one field for creative thought.

It is true that the German State railways were reasonably well managed before the war; but, in the first place, it may be noted that the control was autocratic, and, secondly, that the standard of efficiency attained was not due to creative thought, but to studying and applying the results of the pioneer work carried out elsewhere. This was particularly the case with respect to safety appliances. Indeed, a study of the results of the working of co-operative societies leads to a similar conclusion. So far they have founded no new industry nor made any notable addition to our means of controlling and utilising the great forces of Nature. The whole of the evidence available strongly supports the view that progress in the arts would be slowed to a remarkable degree were private enterprise eliminated.

Another contention of the Fabian school is criticised by Lord Weir. The claim is made that the miner or other worker will, as an individual, work better and at a higher rate of intensity and lose less time if he is in public employment rather than in private service. Lord Weir says that in actual experience there is no substantial difference in the spirit with which a workman works whether he be employed by the Scottish Co-operative Society, the Glasgow Corporation, or by the Fairfield Shipbuilding Company. Indeed, it will be remembered that the low output of certain bricklayers in the direct employment of the L.C.C. gave rise to a scandal some years ago, and the state of affairs disclosed by the report on the Leeds municipal strike in 1913 showed great slackness amongst the employees of that city. Facts, it has been said, are stubborn things, but the stubbornness with which the would-be social reformer ignores them is still more astonishing.

A further claim which Lord Weir demolishes is that Government control would abolish over-lapping. Speaking in the fulness of his experience, Lord Weir states that there are many water-tight departments in Government offices, and overlapping is by no means rare. It may be added, moreover, that overlapping is not necessarily an evil. For instance, it may happen that the same problem is being considered by independent minds, each with power and authority to conduct its own enquiries and make its own experiments. What one man may deem to be insignificant, another, conducting the same research, may prove to be of first-class importance. A striking instance of this was afforded by the discovery of Argon, which was the result of a man of genius repeating experiments of a type made many times previously by numbers of skilled analysts. The slight discrepancies they ignored, Lord Rayleigh deemed worthy of further investigation, and thus discovered the first of a whole series of new elements.

Recognising that the prosperity of the country depends upon its productivity, Lord Weir is seriously exercised by the re-imposition of the Union regulations, restricting freedom of employment, which were partially relaxed during hostilities. We believe that a somewhat similar condition of affairs arose in connection with Cromwell's army, whose members, when they sought, on discharge, to engage in various industries, were met with the prohibitions of the Trade Guilds. In that case, we believe, that the soldiers won in the struggle, and if it be true that the Unions are now restricting the engagement of men who have lost their opportunity for learning a trade because they were defending the workers at home, it is to be hoped that history will repeat itself. As matters stand, Lord Weir states that the war demand for the products of the machine shop were in excess of those of the foundry, and that now more normal conditions have been restored an enormous increase is needed in the foundry capacity of the country.

The number of ironfounders, he states, is from 5,000 to 7,000 below the number required to keep our machine shops going, and under present restriction it is not easy to see where the men are coming from. Possibly improvements in foundry practice may enable higher outputs to be attained per head employed, but innovations of this kind are very difficult to introduce.

In another part of his address Lord Weir commented on the very small space devoted to these important industrial problems by the daily press which can find columns wholesale for the reporting and discovery of an unimportant inquiry in the House of Lords, but can hardly spare a paragraph to the setting forth of the pertinent facts connected with the present strike of the ironmoulders. This is the more to be regretted, as public opinion has an enormous effect in bringing such matters to a settlement. Neither workmen nor employers will nowadays hold out against the pressure of well informed public opinion, and it is accordingly of first importance to the country that the daily press should supply complete and accurate data on which this opinion may be based.

THE SMITHFIELD CLUB SHOW.

IN this first year of peace it has been our duty to record and deal with many, exhibitions and shows of which some were yearly events interrupted by the war, and others more occasional projects. In practically all cases the exhibits at these shows have reached a good standard both in quantity and quality, and have afforded indication that our manufacturers are making considerable effort to get their activities on to a peace basis and to surpass their pre-war output. The latest exhibition to which it falls to us to deal is the Smithfield Club Cattle Show, which has been held at the Royal Agricultural Hall during the week, and which closes to-day. The Implement Section of this show is the only one with which we are concerned and in this a good display of tractors, agricultural appliances, &c., had been brought together. From our point of view the Smithfield Show necessarily suffers from the fact that it follows by some few months the greater exhibition of the Royal Agricultural Society, and that a considerable part of the engineering material on view was to be seen at Cardiff. This year in particular the Smithfield Show has also been preceded by the Tractor Trials at Lincoln and the recent Transport Exhibition, so that there was little on view in Islington this week which had not comparatively recently been brought to the attention of our readers.

In giving a brief description of the engineering material which was on view, we may first refer to the lighter type of farm tractor of the class which competed at Lincoln. This type of appliance was represented by exhibits from the Austin Motor Company, Limited, of Northfield, Birmingham; Messrs. John Fowler and Co. (Leeds), Limited, of Steam Plough Works, Leeds; Martin's Cultivator Company, Limited, of Stamford; The Overtime Farm Tractor Company, of 124-7, Minories, London, E.C.1; the Saunderson Tractor and Implement Company, Limited, of Bedford; the International

Harvester Company, of Great Britain, Limited, of 80, Finsbury Pavement, London, E.C.2; and Messrs. Price, Service and Co., of 7, Old Bailey, London, E.C.4. Apart from the exhibits of Messrs. Fowler and Messrs. Price, Service, the tractors of the whole of these firms were described, and most of them were illustrated, in our issue of October 3 last, in which we dealt with the Lincoln Trials. Of the two new exhibits that of Messrs. Fowler of Leeds is essentially a motor plough, and will cut two furrows adjustable from 8½ in. to 10 in. wide and up to 6 in. deep. The plough can, however, be detached and the tractor used for pulling self-binders, mowers, &c. The usual pulley is fitted to enable chaff cutters and other agricultural machinery to be driven by belt. The two driving wheels of the machine are fitted with independent clutches so that either can be disengaged. With the whole drive transmitted to one wheel the machine will turn in its own length and by this means the headland is reduced to from 6 ft. to 8 ft. The tractor has a two-cylinder (4-in. bore by 5-in. stroke), engine, which runs at 1,000 revolutions per minute. Power is transmitted from the engine by a leather faced cone clutch to a gear-box giving two speeds and reverse. The final drive to the road gear is by worm reduction.

The tractor of Messrs. Price, Service and Co., was, perhaps, the greatest novelty in the show. We may, perhaps, be allowed to describe it as a midget tractor. It should prove of considerable service to the small farmer, market gardener, &c., whose establishment is not large enough to justify the cost of a tractor of more normal size. The appliance is built generally on the lines of the larger type of tractor and has two driving wheels and a pair of small trailers. The engine has a single cylinder and develops 4½ brake horse-power, and is fitted with magneto ignition and thermo-syphon cooling. The radiator is fitted in front in the ordinary position. The engine crank-shaft lies in the line of the axle of the driving wheels and the pulley for belt-driving outside machinery is keyed directly on this shaft and is situated outside one of the driving wheel hubs. There is no gear-box and the clutches couple the engine-shaft direct to the driving wheels. A pair of hollow shafts project from the back of the machine and carry handles at their outer ends. These shafts are used for steering, the operator walking behind the machine and holding these handles. The clutch and other controls are also operated from these handles, the connections to the engine being taken through the hollow shafts.

A good display of steam agricultural machinery of the heavier type was made at the show, and the well-known builders were mostly represented. We may mention Messrs. Aveling and Porter, Limited, of Rochester; Messrs. Charles Burrell and Sons, Limited, of Norfolk; Messrs. Clayton and Shuttleworth, Limited, of Lincoln; Messrs. William Foster and Co., Limited, of Lincoln; Messrs. Richard Garnett and Son, Limited, of Leister; Messrs. J. and H. McLaren, Limited, of Leeds; Messrs. Marshall, Sons and Co., Limited, of Gainsborough; Messrs. Ransomes, Sims and Jefferies, Limited, of Ipswich; Messrs. Robey and Co., Limited, of Lincoln; Messrs. Ruston and Hornsby, Limited, of Grantham; and Messrs. Wallis and Stevens, Limited, of Basingstoke. These firms showed their various steam ploughing engines, traction engines and steam agricultural tractors, most of which have been dealt with at one time or another in our columns. A number of them exhibited steam wagons, as did also Messrs. William Allchin, Limited, of Northampton; Messrs. Fodens, Limited, of Sandbach; and Mann's Patent Steam Cart and Wagon Company, Limited, of Leeds. These steam wagons were in the main of the 5-ton variety, but it is worthy of note that these steam wagon builders, most of whom have approached the business through earlier experience with traction engines, have in general made no attempt to follow the lead of the motor car makers. In, we think, every steam lorry exhibited at the Agricultural Hall, traction engine steering and the final chain drive has been retained.

Among the smaller type of engineering material on exhibition there was a good display of portable oil engines of various types. Such well-known firms as Messrs. Blackstone and Co., Limited, of Stamford; Messrs. R. A. Lister and Co., Limited, of Dinsley; Messrs. Petters, Limited, of Yeovil; and Messrs. Robey and Co., Limited, of Lincoln, exhibited material of this kind. Messrs. Robey's single-cylinder vertical two-cycle semi-Diesel engine was, we think, the largest unit shown and made a very fine exhibit. There were also quite a number of the small type of horizontal oil engines made with an open water jacket, easily filled from a bucket, and intended to be kept full during the running of the engine. A 4 brake-horse power British-made engine of this class was shown by the Lion Engine Company, of 158-162, Pentonville-road, King's Cross, London, N.1. The same firm showed a similar type of American built engine of 1½ horse-power. Two exhibits we may refer to in conclusion were the Dixie convertible body for a Ford chassis, which was shown by Mr. W. Shepherd, of Market Bosworth. This appliance consisted of a base carried by the chassis so arranged that the various bodies could be quickly and easily attached to it. The car could thus be converted to a parcel van, a small lorry, a hearse, &c. The other exhibit was a neat display of light overhead runways by Messrs. G. W. King, Limited, of Windmill-lane, Stratford, E.

NOTES.

The Week's Notice to Employees in Controlled Factories.

Attention may be drawn to the decision delivered on Friday last by Sheriff Fyfe for the Glasgow Munitions Tribunal. In this decision it was pointed out that, on the cessation of hostilities, the Ministry of Munitions Act, 1918, kept in force certain provisions of the Munitions Act, 1917, including the clause relating to the week's notice, in order to prevent large numbers of workmen suddenly being thrown out of employment. This provision was still in force in all works employed on, or in connection with, munitions. It did not matter that the actual manufacture of munitions had ceased at the armistice. The character of the work itself determined whether it came under the term munitions. Whatever was, or is, the destination of the work, if it was adapted for use in war, though there might now be little chance of its being so used, it was as much munition work as it was at the time of the armistice, for the purpose of this Act embodying the clause relative to the week's notice. There was still "employment on or in connection with munitions work" in the statutory sense. In such works therefore the week's notice had to be given to men prior to their discharge, or wages in lieu.

Manchester College of Technology.

An appeal, which we trust will meet with a well-deserved response, is made in connection with the proposed extension of the College of Technology of Manchester University. The amount required is 150,000*l.* for the erection of buildings for industrial research and training in applied science and technology. A site was secured some twelve years ago at a cost of 44,000*l.* The equipment will be found by the Governing body, and is estimated to cost about 50,000*l.* It may be stated that some 26,000*l.* of the 150,000*l.* have been assured. The Manchester College of Technology has been among the most useful of its kind in the country. Its accommodation is now overtaxed, and eligible students have had to be refused. Some 500 technical students are now attending its courses. It is estimated that in two years, with the present rate of admission, the numbers will not be less than 850. Manchester, one of our greatest industrial centres, is itself capable of absorbing an enormous number of college-trained men. But Manchester-trained men are to be found not only all over this country, but over the world, and it is hoped that the present appeal will be successful in enabling the college, which has done such practical work in the past, to keep abreast with the needs of the professions it serves.

Benzole as a Motor Fuel.

A report has just been issued by the Automobile Association and Motor Union on the recent test conducted by them, in which a Sunbeam car was run for 10,000 miles on "National" benzole. This benzole conformed to the Association's specification, which embodies the following points: The benzole must have a specific gravity of 0·870 to 0·880. It must give a distillate of at least 75 per cent. at 100 deg. C., of 90 per cent. at 120 deg. C., and 100 per cent. at 125 deg. C. The total sulphur is not to exceed 0·4 per cent. It shall be entirely free from water, and white in colour. In the rectification test 90 c.c. of benzole shaken with 10 c.c. of 90 per cent. of sulphuric acid for 5 minutes shall give only a light brown colour to the acid layer. It shall be entirely free from acids, alkalies and from sulphuretted hydrogen. It shall not freeze at 7 deg. F. The test was very carefully conducted, and stringent measures were adopted to ensure that only fuel conforming to the above specification was used. The lubricating oil used was Vacuum A. The following are the general results, the car weighing 1·8 tons: Average miles per gallon, 24·57; average ton-miles per gallon, 44·22. The average number of miles per gallon of lubricating oil burnt was 1,739·13. It is estimated that the speed throughout the trip was 23·46 miles per hour. The test was intended to be under touring conditions, and no particular choice was made of good roads. The engine was carefully examined before and after the test. The only trouble experienced on the road was with one plug, which, at mile 4,152, had become sooted up. This was taken out, cleaned and replaced. Apart from this the magneto gave trouble towards the end of the trip, and was replaced. As a result of this test it would appear that benzole conforming to the Association's specification is a satisfactory motor fuel.

Flight from Great Britain to Australia.

The Vickers-Vimy-Rolls aeroplane, which, as recorded in our issue of the 7th ult., on page 621, was entered by Messrs. Vickers, Limited (Aviation Department) for the 10,000*l.* prize offered by the Government of Australia for a flight from Great Britain to Australia, left Hounslow on the 12th ult. and arrived at Port Darwin on the 10th inst., having thus completed the journey of about 11,000 miles in 28 days—two days less than the time allowed. This magnificent achievement is undoubtedly the greatest feat yet accomplished in aviation, and is a remarkable testimony to the excellent qualities of the machine and its Rolls-Royce engines. It was also an extreme test of the skill and endurance of the pilot, Captain Ross-Smith, the assistant pilot Lieutenant Keith Smith, and the two mechanics, Sergeants Shiers and Bennett, particularly so as bad weather was encountered at several parts of the journey, and difficult and dangerous landing grounds had to be used in some places. To the men who have accomplished this feat, and also to those who have rendered it possible by skilful design and construction of both the machine and its engines, we offer our sincere congratulations. Full technical particulars of the flight are not yet available, but we understand that the machine has sustained no damage except that a minor fitting of the tail skid was broken by catching on a tree stump at the aerodrome at Singora. The two most notable achievements in aviation—the crossing of the Atlantic and the flight to Australia—thus stand to the credit of the same type of machine, every detail of which is of British design and construction. British aircraft manufacturers can therefore justly claim to have attained the premier position in this branch of the world's industry. Unassisted private enterprise, however, can hardly hope to maintain this position over the present transition period, and this latest demonstration of the possibilities of commercial aviation is, we think, an additional argument in favour of the State aid advocated by Major-General Sir F. H. Sykes.

International Motor Boat, and Marine and Stationary Engine Exhibition.—The date for this exhibition, organised by the Society of Motor Manufacturers and Traders, Limited, in collaboration with the Ship and Boat Builders' Association, Limited, and the British Gas and Oil Engine Manufacturers' Association, has been fixed for March 12 to 20, 1920, at Olympia. Space application lists close on January 5, full particulars of which can be obtained from the Exhibition Manager, Society of Motor Manufacturers and Traders, Limited, 83, Pall Mall, S.W.

LITERATURE.

Technic of Surveying Instruments and Methods, including General and Detailed Instructions for Field and Office Work of Extended Students' Surveys. By WALTER LORING WEBB, C.E., and JOHN CHARLES LOUNSBURY FISH, C.E. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. 1917. [Price 9s. 6d. net.]

THIS book is written to supplement or to remove some deficiencies in the recognised treatises on surveying, by furnishing detailed directions for carrying out specific operations in field and office. The exercises that are given for extending or illustrating the information elsewhere do not permit much scope for originality, but they suggest the necessity for supplying the student with more opportunities for practical work. This is of advantage to the observer, for he will grow more mechanical with greater experience, and as his habits of observation become fixed, his accuracy, in the sense of uniform and exact repetition, will increase. The scheme is apparently designed to enable the observer to trace the amount and source of errors which are introduced by instrumental imperfections on the one hand, and faulty manipulation on the other. As a matter of arithmetic, it is often easy to compute the error in a deduced value that is the consequence of an assumed error in the data, but though the work may be less elegant, it is probably more instructive and more salutary to make a student construct a square with a tape measure and find the closing error. This is one of the exercises actually given, and many others are arranged to exhibit the uncertainty attending the result of a sequence of instrumental operations. Such examples are a very admirable feature, and demonstrate the eminently practical character of the book. This practical character sometimes takes the rather unfortunate form of abbreviations, which may be easily recognised by the American student for whom the book is mainly intended, but are apt to puzzle those who are unfamiliar with the notation. The instructions to a class may be shortened by printing "H" for "horizontal" and "I" for "intersection" but the uninitiated are not a little confused to find "H I" means "height of instrument." This is a slight matter, however, and easily forgotten or forgiven where so much is to be commended.

As instruments have advanced in accuracy of construction, it has become usual in many elementary books, at least, to regard them as perfect, and to neglect the errors that are occasioned by irregularities in form and changes of condition. It comes as a pleasant and wholesome surprise to be reminded of the advantages that follow reversion of the circle or telescope: to be cautioned against errors of division and excentricity, and to find methods described by which the errors may be determined and numerical corrections applied. We only regret that these points have not been more fully insisted upon, and the details worked out with greater thoroughness. In the case of the sextant, the first optical instrument which is described, the explanation is so thorough that one could have wished that the authors had completed their work by finding the angle between the sight line and the perpendicular to the horizon glass, and by discussing the errors produced by the inclination of the index glass, or those arising from a prismatic form. One instrument is not described in this section which might very well have found a place, namely, the camera. The rapidity with which the field work may be registered with proper equipment, the economy of the method and its suitability for topographic surveys in unmapped and uninhabited districts give some distinct advantages to photographic surveying, advantages which are likely to be increased when used in combination with aeroplanes.

The directions for carrying out a series of exercises in the use of surveying methods are generally good, though more space might have been given to stadia topography; the remarks on stadia factors and on the range of errors in the chapter on the technic of surveying instruments are scanty. No clear indication is given of the amount of error that might arise, and be tolerated in this method of measurement. Other work which comes into this section is the determination of azimuth, and one reads with some satisfaction that the United States Government requires that all surveys of public lands shall be based on azimuths obtained by solar observation. This ruling marks a great advance in accuracy, and excludes the use of the magnetic needle, a kind of measurement which the authors correctly and properly describe as in many places worse than useless as a means of determining true azimuth. The trigonometry is of course simple enough, but it seems undesirable to give to sides of triangles such names as "Co-δ" and "Co-h," where Polar distance and zenith distance are unobjectionable if the more familiar declination and altitude are disapproved. In tracing the effect of errors introduced into the azimuth from uncertainty in the latitude or declination, it would have been legitimate and instructive to have derived the parallactic angle, and used the ordinary differential formulæ of trigonometry. It is satisfactory to find corrections for barometric pressure and for temperature introduced into refraction tables intended for use in theodolite work.

The chapter on field and office work required for railway and topographical surveys contains all that is needed for the degree of accuracy proposed. There is little use at this stage in giving a description of the measurement of a base line purporting to have an accuracy of 1/1,000,000, more especially as it may be doubted very much if such a degree of accuracy would be attained with the methods and appliances employed. The measurement of a kilometre with an error not exceeding a millimetre is a feat of no common kind; the difficulties in carrying out such a work suggest themselves without any further remark. The accuracy in the scheme proposed would more nearly approach that attained in the Coast Survey Secondary Standard, in which the closing errors in a triangle might amount to 5 seconds, and the probable error in an adjacent base might be 1/35,000. The degree of accuracy proposed, however, is more than that required in commercial field work, and the object the authors have in view of giving a beginner a practical insight into the work in which he will be subsequently engaged is amply fulfilled. Clearness and decision are promoted by omitting references to exceptions and expedients that may be of importance or suited to particular cases, but to introduce too much detail at an early stage is to invite confusion. The main principles are everywhere insisted upon and, moreover, the student is supposed to be under the direct supervision of an instructor.

Under "Office Exercises" very good descriptions and explanations are given of the pantagraph and planimeter, the latter apparently finding a larger application than in this country. The remarks on verniers and slide rule construction are informing, but some of the rules and formulæ referred to as computational seem trite and out of place. The problems on topographic projection are practical and well selected. The final chapter on Higher Surveying and Probable Error is disappointing. More, and not less, space is necessary as the subject advances in complexity, but in this section subjects of great imporance are dismissed with the utmost brevity. As an example, the whole subject of probable error is compressed into 2¼ pages. Such a treatment is not only unedifying, but may convey a wrong impression. The formulæ given are a correct inference from the theory of probability only when the number of observations is large, and to apply the rule to the mean of six results is misleading. There is not one word to explain what is meant by "weight," and we must assume that in the example the "weight" is the reciprocal of the square of a probable error, not given, otherwise the example is incorrect. Naturally nothing is said of the adjustment of conditioned equations, a problem that comes repeatedly before the student of surveying and topographical problems. The determination of the excentricity of a divided circle, of the error of pivots, and of the correction for runs, offers very good exercises and the discussion is the more welcome as such corrections are too often entirely overlooked in elementary treatises, and here the subjects are treated so briefly, that it is possible the student will fail to follow the process. The authors are making a valuable step in advance, are improving on the lax and imperfect methods that too often do duty for instruction, but it is to be feared that their chances of obtaining a hearing are diminished by the method of presentation. This final section has not been thought out with the thoroughness that marks the earlier portion of the book, and appears as an unwelcome excrescence on a valuable and carefully-compiled manual.

BOOKS RECEIVED.

The Construction of Geographical Charts. By JOHN B. PEDDLE. Second edition, revised and enlarged. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 10s. net.]

Cardiff. A Commercial and Industrial Centre, 1919. An Illustrated Handbook. Edited by D. WILLSON LLOYD, B.A., F.S.S. Cardiff: The Business Statistics Company, Limited. [Price 5s.]

Manual of Meteorology. Part IV. *The Relation of the Wind to the Distribution of Barometric Pressure.* By SIR NAPIER SHAW, Sc.D., F.R.S. Cambridge: The University Press. [Price 12s. 6d. net.]

Man to Man. The Story of Industrial Democracy. By JOHN LEITCH. New York: B. C. Forbes Company. [Price 2 dols.]

Modern Roads. By W. PERCY BOULNOIS, M.Inst.C.E. London: Edward Arnold. [Price 16s. net.]

Examples in Electrical Engineering. By J. F. GILL, M.Sc., and F. J. TEAGS, M.Sc. London: Edward Arnold. [Price 7s. 6d. net.]

Asbestos and the Asbestos Industry. By A. LEONARD SUMMERS. London: Sir Isaac Pitman and Sons, Limited. [Price 2s. 6d. net.]

The Institution of Electrical Engineers. Regulations for the Electrical Equipment of Ships. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 3s. 6d. net.]

Ions, Electrons and Ionising Radiations. By JAMES ARNOLD CROWTHER, Sc.D. London: Edward Arnold. [Price 12s. 6d. net.]

Alternating Current Work, an Outline for Students of Wireless Telegraphy. By A. SHORE, A.M.I.E.E. London: The Wireless Press, Limited.

Telephony Without Wires. By PHILIP R. COURSEY. London: The Wireless Press, Limited.

Scientific Method, its Philosophy and its Practice. By F. W. WESTAWAY. New edition. London: Blackie and Son, Limited. [Price 10s. 6d. net.]

The Hydrogenation of Oils. Catalyzers and Catalysis, and the Generation of Hydrogen and Oxygen. By CARLETON ELLIS, S.B. Second edition, thoroughly revised and enlarged. London: Constable and Co., Limited. [Price 36s. net.]

MOTORISTS AND LIGHTS ON VEHICLES.—On the 9th inst. the Automobile Association gave evidence before the Lights on Vehicles Committee (Ministry of Transport) on behalf of 100,000 members owning motor cars, motor cycles and commercial vehicles. The following is a brief *resume* of some of the important recommendations made by the association: (1) That there should be one enactment dealing with the lighting of all vehicles and cattle to take the place of the various Acts and local regulations which now exist, and that no local authority should have power to make bye-laws relating to such matters. (2) That having regard to the changed conditions created by the transition from horse-drawn to mechanically-propelled vehicles and the consequent speeding-up of traffic, all vehicles, except bicycles and hand-carts, should show two front lights indicating the width of the vehicle. (3) That the exemption of farm carts, &c., during the harvesting season from carrying any lights should be withdrawn. (4) That it is essential in the interests of public safety that all vehicles should show a red light to the rear by means of a lamp carried at the rear. (5) That in the case of vehicles carrying loads projecting to the rear or overhanging the sides of the vehicles, wherever possible the lights should be placed so as to indicate the furthest point of the projection of the load. (6) That the presence of cattle, sheep, led horses, &c., on the road after dark should be indicated by efficient lamps of a distinctive colour, and that the persons carrying the lamps should be required to wave them on the approach of other traffic. (7) That having regard to (*a*) the bad condition of the roads and (*b*) the difficulty of the satisfactory adjustment of rear lamps to motor cycles and push cycles, any new legislation should include a provision to the effect that where a rider could establish that he had taken all reasonable precautions for keeping his lamp alight, he should not be convicted merely because the lamp was out. (8) That as regards the use of powerful lights, there should be some limitation, but that the necessity for efficient lights on country roads (or even town thoroughfares which are inadequately provided with street lamps) cannot be too strongly emphasised. (9) That any new regulations should be phrased in the simplest form, thereby avoiding the commission of technical breaches which in the past have so often resulted from the inability of the public to interpret regulations which were not clear. (10) That the provisions applying to motor vehicles, by which the driver is firstly responsible for contraventions of the lighting law and the owner can also be summoned for aiding and abetting, should similarly apply to horse-drawn vehicles. The Automobile Association also strongly urged that during the past twenty years traffic has been greatly speeded up, and that the adaptation of the lighting law to meet up-to-date traffic conditions would greatly minimise the possibility of road accidents after dark.

SOURCES OF POWER KNOWN AND UNKNOWN.*

By Sir Oliver Lodge, D.Sc., Sc.D., LL.D., F.R.S.

[In his opening remarks the speaker emphasised the importance of Mill's dictum that the whole of human activity on its material side consisted in changing the position of things. As a consequence every form of physical activity demanded power. If this were supplied by heat engines there was necessarily a great degradation of energy and consequent waste. Animals, however, were able to develop energy by oxidising their food without, in the first place, converting the energy into heat so that a much higher efficiency of conversion was realised. The speaker expressed the opinion that there was little prospect for systems of obtaining power from the sunlight by converting its energy into low temperature heat. It would be better, he thought, to utilise it in growing fuel, but he believed that there was a limit to the possibility of utilising in this way chemical and molecular energy. More plentiful and cleaner power was wanted. The production of power from the tides appeared to have little prospect commercially, and he thought that there was greater promise in wave motors, but even in this case he suspected that a detailed study of the question would show that the hope to generate in this way power on a large scale was fallacious. He then considered the question of other possible sources of power.]

Is there any concealed store of energy recently discovered and not yet utilised? There is indeed. There are two—one certain, the other rather hypothetical: the energy of the Atom and the energy of the Ether. I propose to say nothing about etheric energy. If it exists, as I think it does, it is enormous, exceeding the bounds of imagination; but at present it is utterly beyond our reach. Atomic energy is rather inaccessible too, but not hopelessly so. It is far less in amount than etherial energy, but it is immense compared with any form of chemical or molecular energy, such as that derived from combustion or explosives.

By atomic energy I mean the constitutional energy of an atom—the energy which makes it what it is. If this energy is given up in any considerable degree the substance ceases to be what it was, and becomes a substance lower down in the scale. Utilisation of atomic energy would involve the stepping down, the degradation, of matter. The term is purely technical—it has been already applied to energy without moral stigma. All it means is that heavy atoms may become lighter atoms, and in so doing must give off a definite proportion of their great store of energy.

This spontaneously happens in the phenomenon known as radio-activity. If it had not spontaneously happened, we should have known nothing about the energy concealed in an atom. The explosive or radio-active atom has given the secret away. All atoms possess energy, but some cannot hold it all. These are the radio-active elements, and they periodically fire off projectiles with more than volcanic violence. A radium atom firing off a particle, which turns out to be a positively charged atom of helium, is like a two-ton gun firing a hundred-pound shot. That is about the actual proportion between the projectile and the rest of the atom, which naturally recoils each time it fires. The recoil has been observed. Before it has exhausted its ammunition it fires off five such projectiles, and then settles down into a quieter existence as lead—or, if not exactly lead, something chemically indistinguishable from lead. A uranium atom had already fired off four projectiles in order to become radium. Radium is a temporary half-way house between uranium and lead: it is active, but not so fiercely active as some of the intermediate substances which last so short a time that they barely have names. They destroy themselves by their own activity, and consequently are very scarce—like a population with a high death-rate. Radium is of moderate activity; its lifetime is of the order a thousand years, whereas the lifetime of some of the intermediate substances may be measured in weeks or even minutes. Yet they are real elements, with a place in the series, and they have definite spectra and chemical properties.

Do not suppose that the well-known radium is an exceptional substance. It would seem that all substances of very high atomic weight are liable to behave in this way—it is only a question of degree. And it is not by any means their whole energy that they thus exhibit, it is the energy they expend and get rid of—their waste energy—which we perceive. And when we speak of their explosion, it is to be noted that the explosion is not a shattering or bursting of the gun, it is merely the firing of a shot; except that in the atomic case the shot was part of the gun. The energy retained is far more than the energy expended. And when its active transformations have ceased and left it in a stable state, like lead or gold, or silver or copper, or iron or any common element, we are not to suppose that because it is quiescent therefore it has no store of internal energy. Appearances are deceptive. Anyone looking at cordite might think it harmless enough, and so it is till a suitable stimulus is applied. It does not, or at least, it is not wanted to, go off spontaneously. Gunpowder and any other explosive exhibits no trace of its secret to mere inspection; nor do the atoms of ordinary matter show that they are fearfully energetic, but the energy is there.

We may now go on to ask: What corresponds to the gun-powder when I speak of a gun firing a shot? What propels the projectile? It is a very proper question, but at present it can only be partially answered.

There are two kinds of projectiles fired off by a substance—the heavy shot or α ray, which is known to be a helium atom, and the lighter shot or β ray, which is the fundamental unit of electricity, the negatively charged unit particle—an electron. Several electrons may be expelled, and they will not make much difference to the weight of substance left behind, but they will have left it positively charged; and in that case it is liable to fling away one of its massive positively charged particles too. One event follows the other, and whether the electron always escapes first is uncertain. Whichever event precedes, in different cases, the other is likely to follow.

Many circumstances can stimulate the escape of an electron; not, indeed, of the deeper-seated constitutional electrons, but of the outlying superficial charges which are responsible for chemical affinity. Mere friction removes some of them, and leaves the substance positively charged. The removed electrons will have gone to the rubbing substance, and will have charged it negatively. Splashing of water, chemical action in innumerable forms, effects the transfer of electrons, and consequent charging of bodies. Ultra-violet light falling upon clear metal, and indeed upon a large variety of substances, causes electrons to be expelled until the surface is positively charged enough to hold them back. The discharge will go on continuously if more are supplied from a battery. The jostling of the molecules by heat will often cause electrons to escape, but not usually until a temperature of red or white heat is reached. Singularly enough a comparatively low temperature will emit a few positive particles for a time, as it were, but this emanation soon ceases, the material gets tired as it were, and has to be re-born or renewed somehow, if the process is to be continued. Not so with the negative emission from hot bodies. This will go on as long as fresh particles are supplied.

In many ways, therefore, we can stimulate the escape of stray electrons, and it appears that by the aid of X-rays or of projectiles from other atoms, we are beginning to learn how to disturb effectually, and even to eject, the deep-seated constitutional variety; though usually others immediately take the place of the ejected one, with consequent radiation of definite type. If a pair of β particles were permanently extruded an α ray would probably follow in order to restore the neutrality of the atom, and the atom would have gone a step down in the scale. This happens spontaneously, but the result of experience is that we cannot bring about the catastrophe by ordinary means. We cannot alter the spontaneous rate by anything we as yet know how to do. Heating and cooling—alterations of molecular movement—seem impotent to get down to the inner mechanism. Still, we are certain that that inner mechanism is a most energetic system, and just as the internal charges are equally positive and negative, so I believe atomic energy is both static and kinetic—though perhaps not equally so.

The modern view of an atom is a central positive nucleus like a sun, and a revolving system of negative electrons like planets. The electric planetoids, so near this "sun" and subject to its powerful electrical attraction, must be revolving with prodigious speed with a frequency of orbital revolution exceeding in most instances even the frequency of light—a frequency only attained in general by the ultra rapid X-rays. Accordingly these little bodies have plenty of kinetic energy, and when they escape as β rays they do so with something like the velocity of light.

The frequencies possible in a hydrogen atom turn out, in Bohr's theory, to be of the order 10^{16}, being either 10^{16} itself or else $\frac{1}{4}$ of 10^{16}, or $\frac{1}{9}$ of 10^{16}, the denominators being the natural cubes. For heavier kinds of atoms, this frequency must be multiplied by the square of the number allotted to the element in Mendelejeff's series. The diameters of the orbits will be of the order 10^{-8} cm. divided by the atomic number and multiplied by the successive square numbers, 1, 4, 9, &c.

The velocities will be of the order 10^8 cm. per second multiplied by the atomic number and divided by the natural numbers 1, 2, 3, &c.

So for the heavy atoms, whose atomic number is approaching a century, the inner electron speeds are getting near to the velocity of light, and hence probably their instability.

The positively charged nucleus is in different case. Its energy is more likely to be static, *i.e.*, potential, like things held or caught together, as a detent may hold a strong spring. Let these be liberated, and they fly with great violence, presumably under the electrical repulsion; the potential gradient is at first enormous, so that each atom where it strikes a zinc sulphide target makes a luminous splash. Taking the size of the nucleus as comparable to 10^{-12} cm., the acceleration of an α particle is Ne^2/Kmr^2, m being the mass of a helium atom; and this equals $3 \times 10^{23} N^2$ centimetres per second at the start, and must be reduced to near zero at the confines of the atom. (N is the atomic number.)

The projection of an α particle is therefore literally an explosion, and the force can very quickly get up an enormous speed. (The acceleration of a bullet in a rifle is incomparably less.)

The speed with which an α particle is ejected is about one-fifteenth that of light—sufficient to carry it to New York, if there were no obstruction, in a quarter of a second. Its energy is, therefore, weight for weight, a million times that of a bullet. Only because an atom is so small does it fail to do any damage.

But the number of projectiles from a milligramme of radium is about 30,000,000 a second; hence, in the aggregate, they do generate a very perceptible amount of heat. We may not know the exact cause of their retention or propulsion, but no one can deny that the energy is there. The main difficulty is to understand how they are retained and packed together into the minute nucleus.

As to the atom's negative electron energy, that is probably kinetic, they probably escape with the velocity with which they were revolving in their orbits before perturbation. This is rendered plausible by the fact that the emission depends on synchronism between the periods of the particles and the X-ray disturbance which ejects them. Their energy of ejection is found to depend on the frequency of the radiation which stimulates it; a fact which at once suggests a storing of received synchronous vibrations, till a quantum of energy sufficient for ejection has been accumulated. Moreover, spectrum analysis of the derived or secondary X-rays, emitted by a substance exposed to radio-active bombardment, is also a test of the frequency of orbital revolution.

Particles can be ejected from one of several orbits—called respectively K or L or M, the K orbit being the nearest to the nucleus and therefore of highest frequency. Electrons are ejected at speeds still greater than α particles, and occasionally approach to within a few per cent. of the speed of light.

If we calculate the amount of energy thus quietly existing in the atoms of any visible piece of matter, we shall find it enormous. If each atom is the seat of these high velocities, and equivalent high explosive forces, the aggregate of energy in a few trillion atoms is very great; and it takes fully a trillion atoms to make a perceptible speck of matter.

To illustrate the energy possible in any reasonably small quantity of substance, it is sufficient to reckon the energy in a couple of grammes, or, say, 30 grains, of matter moving at one-tenth the speed of light. It need not be moving in the sense of locomotion; internal motion of its parts does just as well; and static energy can be equally well included, since its liberation will produce these high velocities. The energy is 10^{19} ergs. units or ergs. Now a foot-ton is 3×10^{16} ergs. Hence the energy of a few grammes of matter is 300,000,000 foot-tons, enough to raise 100,000 tons 3,000 ft. If all its parts were moving with the speed of light, the energy would be a hundred times greater, but it is doubtful whether bodies can move at quite the speed of light. For, just as a bullet cannot move quicker than a thermally modified velocity of sound, so a body is unlikely to move through the ether quicker than the ether disturbance can get out of the way.

No doubt a large store of energy is there; the practical question is, can we get at it and utilise it? We may even ask: Is any of it being utilised already? I do not think the answer is wholly in the negative; for that the activity of radium, thorium, and other radio-active substances, is employed therapeutically is well known. That was the beginning of practical application of the energy given off.

Atomic energy may unconsciously be being utilised in other ways, too. I have lately put forward an incipient radio-active theory of vision: I surmise that in the retina there must be a substance which can be stimulated into activity by the impact of ether waves of luminous frequency, that the substance then ejects a few of its outlying electrons, and that these stimulate the nerve-endings in their immediate neighbourhood. The way in which air vibrations stimulate the auditory nerve has been fairly made out. It is a question of mechanism; but the way an etherial vibration stimulates the optic nerve has not been made out: it is not a mechanical, but an electrical question. Radiation of light frequency is known to be received and stored until it is able to eject a negative particle with whose orbital frequency it happens to agree. And certainly such a particle when ejected could be depended on to stimulate a suitable nerve-ending.

It is on those lines that I would explain the extraordinary sensitiveness of the eye. For the accumulation of a few million impulses would take no appreciable time, and it is difficult to suppose that in any other way than by synchronisation with equally rapid motion, could matter be perturbed by the extraordinarily rapid vibrations of ether—hundreds of millions of millions per second. Nothing larger than the ultimate elements of the atom could be expected to follow such rapidity. Molecules of matter would be almost too massive and gross to be readily moved as a whole; and, besides, their movement as a whole would only result in heat.

The same sort of idea could apply to the stimulus of a sensitive photographic plate, only here the chemical atoms are attuned, as a rule, to still higher rates of vibration, and are susceptible beyond the ultra violet, into the region of χ and γ rays.

The facts of colour vision suggest that the visual substance (visual purple, of whatever it is) is specially sensitive to three particular frequencies, one in the red, one in the green, and one in the violet; but there must be plentiful overlapping, so that intermediate wavelengths may produce their full effect.

The whole idea at present is in the nascent stage: only it is instructive to think that possibly atomic energy may have been utilised in the eyes of animals all the time. It is conceivable that it may have been utilised for the light emission of glow-worms, though that is generally and perhaps rightly considered to be due to molecular or chemical energy. Atomic energy is not chemical at all, but physical, at least, when the constitutional and not the outlying electrons are in question. It is possible that the absorption of solar energy by chlorophyll in plants may also in some way utilise atomic energy, stimulated into catastrophic activity by light waves. These things are only possibilities, which observers and experimenters may do well to follow up, and, if need be, negative.

But of late an application of atomic properties in vacuo has undoubtedly been made. Ordinary electric valves depend upon the different behaviour of positive and negative particles, and an electric bulb containing a positive electrode and a hot wire cathode was employed, some years ago, as a receiver for wireless telegraphy, by Professor J. A. Fleming. When the hot wire or filament is negatively charged, a stream of electrons

* Abstract of the Trueman Wood lecture delivered to the Royal Society of Arts on December 10, 1919.

reach the anode. When it is positively charged, the emission is checked. So, if an alternating current is received, the emission of electrons is alternatively helped and hindered, and thus the current is rectified and made capable of being received by any ordinary instrument. The cutting up into signals has to be otherwise managed, for the alternations are too quick to be acoustically perceived.

Then Lee de Forrest introduced an improvement and made it not only a wireless receiver but a relay or amplifier. Between negative filament and positive anode, in an exceptionally high vacuum, he placed a perforated grid or coiled wire, with interstices that would let the electrons through; and, instead of applying the received alternating pulses to the anode, he applied them to the grid, placed above or facing the red-hot cathode. The effect on the escaping charged particles was the same, the stream of current-carrying particles was helped or hindered, encouraged or stopped, as before; but now a strong battery could be applied between anode and cathode, and some mechanical receiving instrument, telephone or what not, could be placed in the auxiliary, or relay circuit. Weak impulses applied to the grid, according to their positive or negative sign, will now serve to control the stronger current in the auxiliary circuit; and so a received message that in itself would be hardly audible can be magnified a hundred-fold.

Electrons emitted by a hot wire are not flung off with any prodigious speed: they seem rather to evaporate off at a red or white heat, and their subsequent course is controlled by the gradient of electrical potential in which they find themselves. The force acting on them is $F = e\,d/V\,d\,x$, and the total work done is $F\,d\,x = e\,d\,V$; that is to say, the energy generated depends simply on the total drop of voltage through which they pass. Their speed is given by

$$\tfrac{1}{2}\,m\,v^2 = e\,(V - V^1),$$

and it is usually considered sufficient to specify the voltage through which they drop as adequately representing their externally generated speed.

They come off with *some* velocity, however, call it u; but a small opposition voltage will suffice to quench this, as gravity quenches the speed of a cricket ball thrown vertically up, and sends it down again. So it is with the electrons from a hot wire. Any potential difference greater than $m\,u^2 / 2\,e$ will return it whence it came. One volt rise in potential would be able to quench a speed of 450 km. per second.

That, then, is what happens between grid and hot wire. If the grid potential is negative, and greater numerically than the minimum value, the stream of electrons from the hot wire is stopped and sent back: if the grid is positive, the speed upward of the electrons is encouraged. They shoot through the pores of the grid, they reach the anode above it, they establish connection and convey the current. The auxiliary circuit, between anode and hot wire, is completed by them, and the signal is given. But this only happens when the grid allows of their passage. If the potential of the grid is adverse they never pass through it at all, but just return depressed to the hot wire. Electric evaporation is checked, just as the evaporation of water is checked in a closed space, not because no particles spring out, but because an equal number are returned. A positive grid promotes evaporation, a negative grid checks it, an alternating grid causes an alternating stream to pass through it; and the electric stream can follow every minutest fluctuation; for their inertia is as nothing, and they respond instantly to the slightest force.

To get quickness of response the projectiles must not be allowed to bombard other molecules, so as to ionise them and render the whole atmosphere conducting. For this ionisation would not subside instantaneously, and therefore the current would not be completely under control. To avoid ionisation by impact the reservoir must be very highly exhausted, and the current ought to depend on the projectiles themselves, not on their secondary and adventitious effects.

It is to be noticed that the kind of electric emission from a hot wire differs greatly from that stimulated by ultra-violet light or X-rays. These vibratory agents dig right down into the constitution of the atom, and eject electrons whose orbital frequency agrees with their own. The "harder" the ray, that is, the higher the frequency of the impinging radiation, the higher the velocity of the ejected electron—evidently because one of the innermost orbits is then perturbed. For in inner orbits the speed must be high, in accordance with Kepler's third law. The orbital speed varies inversely with the square root of the radius of the orbit. And the more massive the nucleus the greater the speed necessary to balance the centripetal force.

But the jostling of atoms by heat produces no such deep-seated effects. The effect of heat is as if a kind of atmosphere or crowd of stray electrons, in a metal, evaporated and escaped. It is unlikely that the electrons in a metal are really loose, but some of them are so slightly attached as to be practically loose—readily passed from atom to atom in the process of conduction and readily expelled under the irregular impulses of heat.

Whether heat is the best way of promoting this electronic emission may be doubted. It seems an extravagant method, analogous to employing an electro-magnet where a permanent magnet would do, or to supporting a roof by a jet of water. But the other kind of stimuli, such as those promoted by radioactivity or ultra-violet light, do not seem to generate the right kind of docile emission. The very high speed electrons would require too much potential to hold them down. The speed of electrons ejected by χ or γ rays is definite, and depends on the frequency of the rays; but the speed of emission of electrons from a hot body is indefinite and irregular, being distributed in accordance with Maxwell's law for a monatomic gas. Moreover, the escape through the skin of a metal is equivalent to an escape against a "contact" difference of potential; and thus, in some cases, the electrons may be said to ooze rather than to fly out, and to owe their subsequent speed entirely to the external potential gradient in which they find themselves.

That state of things would be quite convenient for wireless telegraphy, since they would then be still more readily under control. The skin retardation exerted by tungsten has been measured as 4·6 volts, unless I am mistaken.

To return to practical applications of these atomic properties—for it is atomic properties rather than atomic energy that is at present being utilised. Not only is it possible to employ a relay in the way described, for the emission and receipt of wireless waves, but one relay can be used to stimulate another; and this can be done several times in succession, and immense magnification attained; for the electric stream is so rapidly responsive and docile that it can follow fluctuations that no mechanical relay could possibly follow. The rapidity of signalling thus rendered possible in the Morse Code is surprising. Of course an automatic sender, and some form of chemical or quick-responding receiver, must be used; and then the message can be as rapid as one can speak. The words are spelt out, without abbreviation, in dots and dashes; and yet the words come on to the tape at 300 a minute, five a second or thereabouts.

It is also becoming well-known that Morse signals need not be used, but that ordinary speech itself can be thus wirelessly but electrically transmitted, with quite good clearness of articulation. Every auditory frequency is slow compared with what the atomic projectiles can follow, hence every variety of speech sounds, vowels and consonants, can be readily picked up and transmitted into electric fluctuations. This is done at the sending end, and the aerial accordingly emits waves, which, though they have their own electric rate of vibration, succeed one another in batches corresponding to the acoustic frequencies. At the receiving end the succession of waves are picked up by the aerial there, and once more converted back into telephonic speech through the mediumship of one or more valve relays and appropriate devices.

There are many details, and great ingenuity has been expended in bringing this method of wireless telephony to the perfection which it has thus far attained. The whole thing is most hopeful, and splendid work is being done at wireless research stations. I have recently seen the Government one at Woolwich, under Colonel Cusins, and a devoted staff of workers, and have gone over it with great admiration.)

The interest to us, here and now, is that it is by the harnessing and practical utilisation of purely atomic properties, that all this great advance in practical electrical engineering has been accomplished. The conclusion is inevitable that much more remains to be done.

"OIL POWER."—This is the title of a new monthly periodical in pamphlet form now being issued by Messrs. Plenty and Son, Limited, Newbury, "to interest those who now use or contemplate using oil as fuel for power purposes." The first issue, for the present month, contains articles on "The Advantages of Oil Power for Small Vessels," on "Fuel Oil," "Oil *versus* Coal," &c. The price per issue is 3*d*.

ELECTRIC FURNACES.—Messrs. the Automatic and Electric Furnaces, Limited, 281–283, Gray's Inn-road, W.C. 1, state that as a result of lengthy experiments in their laboratory, extending over two years, they have now succeeded in obtaining a perfectly non-porous metal container for their electric salt-bath furnaces, which permits the current to be switched "on" and "off" when desired. The new metal furnace pots are easily replaced by simply lifting the furnace up, and removing the pot. With current at 1*d*. per unit, a ton of tools can be hardened for the small cost of 2*l*. 4*s*. The use of metal pots of this description, introduces an entirely new development in electric resistance furnaces. In addition to their existing patents covering the heating coil, &c., the use of a suitable metal pot is also the subject matter of a provisional patent.

THE PATENT OFFICE LIBRARY.—A petition, addressed to the President of the Board of Trade, is being circulated asking him to authorise the reopening of the Patent Office Library to the public until 10 p.m. daily, as was the practice for over twenty-five years before the war, viz., from about 1888 to 1914. The Patent Office Library, the petition states, is maintained from national funds; it is acknowledged to contain the most valuable collection of current and other technical literature in this country, and is consulted daily by a large number of readers. Unfortunately the hour for closing prevents the fullest use of the library being made by many readers who are engaged during the day time in chemical, engineering and other technical works, in the outskirts; and these readers are therefore deprived of access to information that they cannot obtain elsewhere. The signatories add they are aware that it has been decided to open the library until 8 p.m. from the 1st inst., but they believe that, in regard to this, the authorities of the Patent Office have not fully appreciated the position of the aforesaid readers, who cannot reach the library until a comparatively late hour. Moreover, these readers belong to a class that should be specially encouraged at the present time, when there is great need for improvement in the technical condition of our industries. They conclude by stating that to exclude them from the sources of information contained in the Patent Office Library is, therefore, adverse to the national interest.

"THE BRINELL AND SCRATCH TEST OF HARDNESS."

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the article by Dr. Unwin in your issue of November 21, and subsequent letters by Mr. Newman and Mr. Innes, the following remarks giving my experience of the scratch test may be of interest or use to your readers.

Mr. Innes is right in asking for an exact definition. In your issue of May 17, 1918, Dr. Unwin quoted Osmond's definition of hardness as "The resistance to permanent deformation," and in Sir Robert Hadfield's contribution to the report of the Hardness Tests Research Committee Sir Robert Hadfield gives the definition as simply "The resistance to deformation." This is clearly the correct and accepted definition, but to render it absolutely accurate I think it requires to be amplified slightly, and should read: "Hardness is the resistance of a surface to deformation by mechanical means." I think the word surface must be used because in hardness testing we always deal with the surface. After deformation the surface may not occupy the same position, but is still the surface. Then, mechanical means must be specified because heat or chemical means can deform the surface without any relation to its mechanical hardness.

Coming to the scratch test, I was led to make some experiments a few years ago by the following circumstance. I had several thousand case-hardened articles to examine, and amongst other details to test them pretty carefully for hardness. Owing, to the shape of the pieces neither the Brinell machine nor the scleroscope were very convenient, and in any case such methods were much too slow. I therefore applied the scratch test as follows: At that time I was in favour of the scleroscope scale. I hardened and drew down a set of cast steel blocks to correspond to hardnesses 95, 90, 85, 80, 75, 70 and 60. I tested them, both on the scleroscope and Brinell machine, to get them as correct as possible. I then made a set of scratchers or "testhards," as I named them, and tempered each just scarcely to scratch its corresponding block. It would, of course, scratch the block of next lower hardness.

These I made of $\frac{1}{4}$-in. square bar, about 6 in. long, turned down at the ends and marked on one side of the square part—"Will cut if under 90."

With this set the testing could be performed like a flash. The 95 "testhard" was hardly required, but taking the 90 one, it was not really necessary to scratch the article; immediately the tester touched the surface it would either decidedly slip or bite in. In the latter case, of course, another tester was tried until the hardness was found. The step of 5 per cent. was quite as close as could be conveniently judged by this method.

The above led me to make a few experiments to see whether some scratch method could be got out to establish a proper hardness test. I constructed a timber arm about 2 ft. long, having a trammel centre at one end and a scratching tool at the other end, with provision for loading the tool as required. I used two shapes of tools, one square at the point, 1 mm. wide, the other right-angled, each with about 10 deg. of forward rake, so as to scratch and not cut.

I experimented on soft lead, copper and wrought iron. The force required to pull the tool along was measured by a spring balance and I tried to calculate the volume of material ploughed out. I measured the rectangular scratch by filing it to the bottom and taking the depth by a micrometer. The angle scratch I measured by taking the width with a microscope.

I then co-related the volume per centimetre length, so obtained the kilogramme-centimetres of work expended, and by averaging out got results somewhere as follows:—

1·8 kg.-cm. to scratch out 1 cub. mm. lead.
21 kg.-cm. to scratch out 1 cub. mm. copper.
36 kg.-cm. to scratch out 1 cub. mm. wrought iron.

But the measurement of the scratch was difficult and unsatisfactory, even when dealing with these soft materials, and I considered if really hard materials were attempted on the same lines, instruments would have to be adopted quite beyond practical work.

From the above experience I came to the conclusion that the scratch test forms an excellent secondary method of testing to within, say, 6 per cent. or 8 per cent. but for actual measurement as a fundamental method it is impracticable.

Yours faithfully,
R. M. LESLIE.

88, North-road, Highgate, London, N. 6.
December 8, 1919.

"FLAME VELOCITY IN INFLAMMABLE GASES."

TO THE EDITOR OF ENGINEERING.

SIR,—In a recent issue of ENGINEERING, Mr. J. D. Morgan has advanced a hypothesis to the effect that the speed of flame in gaseous mixtures is proportional to the pressure produced ("Flame Velocity in Inflammable Gases," October 24, 1919, page 535). This hypothesis is intended primarily, I believe, to apply to the propagation of flame in closed cylinders, regarding which Mr. Morgan contributes some experimental data in support of his theoretical deductions.

The normal speed of propagation of flame by conduction of heat from layer to layer of the mixture (the so-called "uniform movement") has been shown by Mallard and Le Chatelier ("Ann. des Mines," 1883 (viii) 4, 274) to vary, for a given combustible gas, directly with the heat of combustion of the mixture. The pressure produced by an inflammable mixture burning within a closed vessel is also directly proportional to the heat of combustion of the mixture. Mr. Morgan's

hypothesis thus implies that the mode of propagation of flame within a closed cylinder is essentially by conduction of heat from layer to layer of the mixture. This may be so with cylinders of small diameter in which the action of convection currents is suppressed; and under conditions of ignition which avoid the creation of turbulence in the mixture. Insufficient experimental data are available to test the matter.

When, however, an attempt is made to extend the hypothesis to the propagation of flame in open tubes, regarding which a considerable amount of experimental data has been collected, the facts do not support the theory.

Yours faithfully,
W. Mason.

Home Office Experimental Station, Eskmeals, Cumberland, December 5, 1919.

"CONTINUOUS BEAMS WITH END LOAD."

To the Editor of Engineering.

Sir,—In your issue of November 21, Mr. John Case draws attention to the fact that the extension of the generalised theorem of three moments for a beam under lateral and end load to include deflection of the points of support was first published by him in *Aeronautics* of October 30.

I should like to state that I have since read the article referred to with much interest. I must, however, take exception to his statement, in your issue of November 21, that the "Generalised Theorem of Three Moments," as stated by me in your issue of November 14 was incorrect as regards the deflection term:

$$\left(\frac{1}{l_1}+\frac{1}{l_2}\right) E\,I\,\delta.$$

As I mentioned in my letter of November 14, δ in the above expression is the deflection of the intermediate point of support of *any* two bays under consideration *measured from the straight line joining the two extreme supports of the same two bays.*

It will at once be evident that Mr. Case's last term

$$E\,I\left(\frac{\delta_B-\delta_A}{l_1}+\frac{\delta_B-\delta_C}{l_2}\right)$$

has exactly the same physical meaning where δ_A, δ_B and δ_C are measured from a fixed datum line, since:

$$\delta = \delta_B - \left[\delta_A + \frac{l_1}{l_1+l_2}(\delta_C-\delta_A)\right].$$

Hence the theorems as given by Mr. Case and as given by myself are essentially the same, and the one will be as general in its application as the other. It is possible that his form of solution would be more convenient in use in some applications.

Yours faithfully,
G. W. Higgs-Walker.

3, Russell-road, Hendon, N.W. 9,
December 2, 1919.

THE GENERAL FLOW OF WATER IN OPEN CHANNELS.

To the Editor of Engineering.

Sir,—In order to obtain a workable knowledge of water flowing in a channel, it is necessary first to consider water flowing unconfined through a lake of considerable depth and width, as this is the simplest case of flow.

Suppose the water entered the lake by flowing over a weir and left the lake in the same manner, leaving out of consideration the effect of the water flowing into the lake over the weir and considering only the general flow through the lake, it is necessary to consider, firstly the direction in which the water would flow, secondly the pressures that cause the movement of the water, and thirdly the retarding forces.

As regards the first, it would seem that unless the water for some reason or another, has to flow in any other way, it would flow from inlet to outlet in a direct line and spread out on the surface until the depth of the flowing water was small. It would do so, as this is the path of least resistance.

As regards the second, the force that moves the water must be the draw of the water flowing over the weir. Every particle of water that flows over the weir reduces the pressure in front of the following particle and causes it to move, but if the following particle cannot move quickly, owing to some cause or another, the pressure on the particle in the directions in which it is moving will be less, and its movement will be retarded until the pressure in front is still further reduced. In order to make this clear suppose a particle was at rest and the pressure on all sides was, say, 12 lb., if the pressure in front was reduced to 11 lb., the particle would move in the direction of the decreased pressure, but if the particle behind could not move at the same pace the pressure behind would be reduced to 11 lb., and there would be an equal pressure on both sides of the particle, which would bring it to rest, until the pressure in front was reduced to 10 lb., when the particle would again move. If this is followed to its natural conclusions, all the particles would move with equal velocity from inlet to outlet, and if the particles in any section of the stream were in any way retarded, the movement of all the particles in the stream from inlet to outlet would be affected, resulting in a decrease of the velocity of the water flowing over the weir.

As regards the third, if it is allowed that the particles are retarded by some constant force acting along the whole distance from inlet to outlet, in the absence of any accelerating force such as that caused by surface fall, the velocity of the water flowing over the weir would depend upon the total resistance of the retarding force which in its turn would depend upon the distance from inlet to outlet. Hence, if there was any appreciable resistance to flow without any appreciable surface fall the flow over the weir at the outlet would depend on the distance between the inlet and the outlet. No surface fall from inlet to outlet has been observed, nor is there any known difference in the flow over the weir at the outlet depending on the distance of the inlet from the outlet, consequently it would seem that there is no other resistance to flow than that of overcoming the inertia of the water, due to increase of velocity as the water flows over the weir.

The resistance of turbulent motion, due to eddies or puffs, is known to be absent as there are no sign of the puffs coming to the surface, and the only other possible resistance is that which is sometimes called friction and sometimes viscosity. Both friction and viscosity would be a resistance between the body of water moving from inlet to outlet and the surrounding still water. Now it would seem that if there were any resistance due to friction or viscosity, some of the still water would be set in motion, and the volume of the stream increased almost indefinitely, as the water so moved would move other bodies of water. It seems inconceivable that there should be any increase in volume and consequently friction or viscosity seem equally inconceivable. When water is confined in a pipe or by the rigid sides and bed of a masonry or wooden channel, it is conceivable that there might be a resistance due to viscosity or friction, as there would be no change of volume unless a portion of the wetted area was occupied by still water, but with water flowing in contact with easily-moved particles of still water it is hard to understand that there can be any resistance without increase of volume.

Experiments to determine viscosity and friction seem to be carried out by revolving a disc in water and measuring the energy of the disc that is conveyed to the water. Until it is known how a solid communicates its energy to a fluid it cannot be said that the energy is conveyed by means of viscosity. There is undoubtedly a certain amount of adhesion between a solid and a fluid, but this may be due to other causes than viscosity. For instance, a plate of iron will adhere to another plate of iron if the two surfaces are smooth and true. The fact that there is a certain amount of air mixed with water, probably accounts for a certain amount of adhesion between water and water and between water and a solid under certain circumstances. Whatever may be said about viscosity or friction it seems better to treat water as a perfect fluid, which has no viscosity or rubbing friction, and add their effect afterwards if it is found necessary. In the case of water flowing through a lake it does not seem necessary, and even creates difficulties. If the water flows through the lake without any resistance the particles of water would flow parallel to one another with equal velocity, and there does not seem to be any proof that they do not.

Suppose the stream of water passing through the lake were contained by banks, the depth at which the water flowed would be increased in proportion to the decrease of width. When the water flows with an increase of depth the pressure energy of the lower layers is greater than that of the upper layers, consequently the velocity of the lower layers will be greater than that of the upper layers. Directly any body of water obtains a velocity which is higher than the velocity of the water surrounding it, the body of water has a tendency to flow towards the surface, as this is the path of least resistance. The result of this is that small bodies of water in the form of puffs are constantly coming to the surface from the lower layers, these puffs as they pass through the different layers of water cause a retardation to flow, and constitute turbulent motion.

Thus a constant retarding force is set up and a constant accelerating force becomes necessary in order that the water may flow. The constant accelerating force is obtained by means of surface fall. The net result of confining the stream is, that turbulent motion is set up and surface fall becomes necessary.

If the containing banks are parallel the water will flow, at the same depth throughout, over still water of any depth, and will only flow in contact with a solid at the sides. If it were otherwise there would be an increase of volume, which seems impossible. Now suppose the water entering the channel formed in a lake brought with it solid material usually called silt, the silt would be deposited at the bottom of the still water until it came in contact with the flowing water, if the deposit of silt continued it would raise the surface of the water. It is known from practical experience that the surface can be raised only by some rigid structure that cannot be scoured away, and it seems impossible that any silt could be deposited under such conditions or would remain if deposited, consequently the surplus silt must be carried forward and pass over the weir at the outlet. Now if there is any resistance due to friction or viscosity between the water and the silted bed, it could be discovered by measuring the surface fall and discharge before and after silting has taken place. At present there does not seem to be any evidence that there is any change. If there was any resistance to flow due to viscosity or friction between the flowing water and the silted bed, it is hard to imagine that fine particles of silt could be deposited under such conditions and grains of sand would be rolled along the bottom. As regards the sides of the channel, if there was any resistance caused by the water flowing in contact with the sides, a portion of the energy of the water would be conveyed to the material forming the sides and this would cause a certain amount of wear on the sides. Wear is the natural result of frictional resistance, and one cannot happen without the other. In this case, if the earthen sides of an old channel are examined, it will be found that it consists of thin layers of silt just like a wall that has received many separate applications of whitewash, which seems to prove that there is no wear, but that the velocity of the water at the sides is very small and is retarded by some other force than the frictional resistance of the water flowing in contact with the sides, that force being turbulent motion. It would be quite conceivable that when water flows in contact with unerodable substances like wooden boards, masonry, &c., for friction or viscosity to cause a resistance without causing any appreciable wear, except that due to solids moved by the water, but not with soft wet earth which gives way to the softest rub. Solid projections such as sticks and weeds in earthen channels and the projections of masonry works have their own resistance, and naturally reduce the velocity of the stream, but there seems to be no resistance caused by the water flowing in contact with the earth. If there is no resistance caused by the water flowing in contact with the earth, it does not seem possible for there to be any resistance between water flowing in contact with still water.

Various coefficients have been formed for different roughnesses and, generally speaking, they may be divided into two classes, one where the water is contained by unerodable substances like wooden planks, masonry, &c., and the other where the water is contained by earthen banks and bed which are erodable. In the latter case, the natural conditions of flow are possible, as scour can take place, but it is hard to obtain the natural conditions of flow in a channel with an unerodable bed, consequently a higher velocity can be obtained in a channel which has an unerodable bed, than in a channel that has an erodable bed. When water flows over an aqueduct of less dimensions than the earthen channel above and below it, the aqueduct forms an obstruction and the velocity is increased in the same way as it would if there was any other masonry obstruction.

Suppose the crest of the weir at the outlet were lowered and no silt had been deposited on the bed, the whole surface of the water in the channel might be lowered or the surface fall increased; in either case, the bottom layer of the flowing water would still flow parallel to the surface. If silt had been deposited and the water were flowing in contact with the silted bed previous to the lowering of the crest, either the silted bed would be scoured out or it would form an obstruction to the natural flow and the bed might be said to raise the water above its natural level. Practical experiments show that, if it is desired to raise the surface of the water in a canal, the mere throwing in of earth is useless, it would be scoured away, and a strong masonry work is required to raise the surface. It would therefore seem that the bed would be scoured out until the natural surface fall is possible.

Suppose the crest of the weir at the outlet were raised to its former level, the surface would be again raised to its former level, and the wetted area not required by the current would be filled with silt.

The question as to whether the lowering of the crest of the weir at the outlet would result in a lowering of the surface bodily throughout or in increasing the surface fall, seems to depend on whether the conditions at the commencement of the channel allow scour or not. If there were an unerodable apron at the commencement of the channel that controlled the surface there, or the conditions otherwise fix the surface level, there would be an increase of surface fall, but if there is nothing to control the surface level at the inlet, the surface will be bodily lowered and the surface fall will be the same as if the crest of the weir at the outlet had not been lowered.

To sum up the above:—

The surface fall is necessitated by the resistance due to turbulent motion, and is otherwise determined by the differences of level at the commencement and end of the channel.

The sectional area of the flowing water may be equal to or less than the wetted sectional area.

The depth of the flowing water is equal to the sectional area of the flowing water divided by the width and is independent of the depth of the water in the channel.

The retardation is due to turbulent motion and any projections into the stream that will resist the action of the water.

It may be noted that silt and scour are Nature's methods of creating a channel suitable to the natural flow, and have no direct connection with the velocity of the stream. When the channel has silted or scoured so as to be suitable to the natural condition of flow, the channel is said to be in a state of "régime," and the channel remains in this state until the conditions of flow are altered.

I am, yours truly,
L. L. Wickham.

Mineral Production of the United States in 1918.—Though the total quantity of minerals mined in the United States in 1918 was smaller than that of 1917, the total value of 5,526,000,000 dols. exceeded that of 1917 by half a billion dollars. The coal mined indeed rose by 5 per cent. in 1918, apart from a decrease in anthracite, but the value increased by 17 per cent. There was also an increase of 4 per cent. in the oil production, very much smaller than the rise in value, however, which amounted to 32 per cent. The iron ore output and steel production showed a slight decrease, though more pig-iron was made. As regards copper and zinc, two great war metals, the prices fell during 1918, zinc by 25 per cent., and the output increased only in the case of copper. In the case of chromite and manganese the outputs rose by 88 per cent. and 275 per cent., and the prices by 136 per cent. and 100 per cent. respectively. Against these increases is to be recorded a falling-off in the production of gold and silver, and in all building materials.

VALVE FAILURES AND VALVE STEELS IN INTERNAL-COMBUSTION ENGINES.*

By LESLIE AITCHISON, D.Met., B.Sc., A.I.C.

IN speaking on the subject of valves for petrol engines the author feels that he is discussing a subject of practically universal interest, and one which cannot be treated too seriously. Whilst engaged as Metallurgist to the Air Board, the various difficulties which occur in this connection came before him in many ways and impressed upon him the desirability of treating the subject of valves as a coherent whole, so that, if possible, rules and regulations regarding this important part of a petrol engine could be laid down and adhered to. The author has approached this problem from the metallurgical, and not from the engineering, point of view, as he can claim some knowledge of the former, but little of the latter. He has always endeavoured, however, to obtain the engineering view, whenever possible, from competent sources, as it is essential that it be combined with the metallurgical if the best results are to be obtained. He must necessarily, however, plead for forbearance when he refers to engineering matters, as his principal knowledge and interest lie in the steel from which the valves are made. He is fully aware, nevertheless, that a very large proportion of valve troubles occur in consequence of engine design, and he will refer to these as they arise.

Conditions of Working.—The author's purpose in this paper is to state as fully as possible the different troubles which arise in connection with valves, and to indicate as well as may be the steps which should be taken in order to overcome them in the most likely manner.

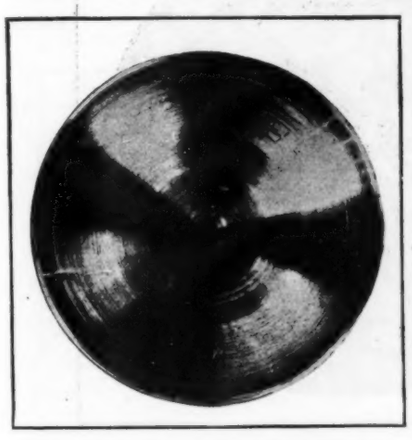


FIG. 1. PHOTOGRAPH OF VALVE HEAD SHOWING RADIAL CRACKS IN FACE.

To do this it is necessary to refer to the actual conditions under which the valves in petrol engines have to work, and to point out how these conditions may affect the valves adversely.

In the first place it is essential to take into account the fact that the valves in petrol engines have to work at temperatures considerably above the normal. The temperature of inlet valves may vary from about 100 deg. C. to about 600 deg. C., whilst that of exhaust valves may vary during normal running from about 250 deg. C. to about 860 deg. C. In aero engines and the hotter automobile engines the latter temperature is frequently attained, and though the majority of the hotter type of engines work at about 700 deg. to 760 deg. C. the temperature of the valves is not the same in all engines of this type, since the conditions of cooling vary considerably. The different engines may be classified roughly as follows: (1) Rotary, (2) air-cooled radial, (3) air-cooled stationary, (4) water-cooled stationary.

Of these the rotary engines are usually the coolest, and the air-cooled stationary the hottest. Probably the other two classes of engine produce fairly similar temperature conditions in the valves and lie between the other two extremes. As stated above, all the engines in one type do not produce identical conditions in the valves, the variations in design, brake horse-power and mean effective pressure affecting the results considerably.

Bearing in mind the elevated working temperature of the valves, it is of some importance to consider the ways in which a valve may get rid of its heat, as this action may be considered to control the temperature of the valve. As the temperature of the valve is highest in the head, this part of the valve is the most vital, and is the portion from which heat must be dissipated as expeditiously as possible. There are three distinct ways in which the heat may be removed from the head of a valve: (1) By being conducted down the stem of the valve and lost by way of the guide, &c.; (2) by direct radiation from the back surface of the head or the neck of the valve; and (3) by direct conduction from the face to the valve seat. Experiments have shown that by far the greatest proportion of the heat from the head is removed by the third method, i.e., by conduction through the face, and it is essential that this mode of cooling be examined most carefully. In this method, the dispersal of the heat is effected by the direct metallic contact of the valve head with the valve seat. For proper cooling two things are essential, first, that the two surfaces shall come accurately together, and, second, that the valve shall be closed at the moment of ignition. The first point is dealt with more fully below under No. 2 of "Types of Failure of Valves," but the second is probably even the more important of the two. The most prolific causes of trouble in valves are undoubtedly those produced by pre-ignition in the cylinder. If the valve is not properly seated at the time of the explosion, then there is bound to be a rush of gases round the valve, and this will take place at the time that the gases are near to their maximum temperature. Under these conditions the cooling of the head of a valve is interfered with most materially and harm is bound to ensue. The author has examined valves which have failed in consequence of pre-ignition and which must have been raised to a temperature of at least 1,150 deg. C. during the process. It can be stated almost without question that the conditions resulting from pre-ignition are responsible for more failures of valves than any other cause.

Although the amount of heat lost by the other two channels is not a very high proportion of the whole, it is desirable that attention should be paid to them, as their effectiveness may represent just that small amount which makes the difference between success and failure. Cases have been examined in which the exhaust ports of an engine were so arranged that the exhaust gases played directly—were, in fact, almost concentrated—upon the valve stem near to the neck. In consequence, the neck of the valve became seriously overheated, becoming, indeed, a good deal hotter than the head. Under these conditions heat was actually being supplied to the valve head by the stem instead of being taken from it. The result in these engines was that the valves were burning out regularly. It is also of some importance that the valve guides, which help in the removal of the heat from the stem of the valves, should act efficiently. If they are so long that they jut out into the exhaust pocket and become heated in themselves, it will be difficult for them to exercise their functions in the proper way. The provision of a sufficient clearance between the stem and the guides is of equal importance.

Another factor which gives rise to trouble in valves is the use of improper mixtures. The author does not feel that he can say anything useful on this subject, as it has been dealt with by many better qualified persons than himself, but he wishes to note it among the frequent causes of failure. Many instances of valve failure have been attributed to bad steel, when the real cause of the trouble lay in the fuel.

Another factor in the conditions governing the working of the valves—the wear between the guides and the stem of the valves—varies in the different types of engines. In the stationary or the radial engines, the cylinders being fixed, the track of the valve head is simply backwards and forwards along a straight line, and the only sideways thrust on the stem is that produced by the design of the cam and tappet action. This may be very slight or on the other hand may be appreciable, but its effect is rarely so serious as that produced by the conditions applying in the rotary engines. Here the path of the valve head is by no means rectilinal, and there is a very distinct sideways thrust produced by the inertia of the rotating system. This has to be taken carefully into account.

Types of Failure of Valves.—There are many ways in which valves actually fail. They may be codified as follows:—

1. Elongation of the stem of the valve.
2. Distortion of the head of the valve.
3. The presence of cracks in the valve face.
4. Excessive wear of the valve stem.
5. Excessive wear of the valve foot.
6. Burning out of the head.
7. Scaling of the valve.
8. Breaking of the head or neck due to self-hardening.

All these causes have some metallurgical significance, and the author proposes to deal with each one more fully, and then to attempt to draw out the properties which the steel must possess which is to withstand all these different probable causes of failure. Apart from the details of design of the engines, all the methods of failure indicated above have some definite connection with the properties of the steel.

1. Elongation of the stem of the valve is not a form of failure which very often occurs. When it does happen it indicates one of three things, namely (1) the employment of a steel of insufficient strength at the working temperature, (2) overheating of the stretched part, or (3) an unsatisfactory design of the neck of the valve. The author has examined cases in which the stretching has occurred to the extent of ¼ in. during a few hours' running, and this usually occurs in the neck of the valve, this part being narrowed considerably in the design. The first cause, namely, the strength of the steel, will be dealt with quite fully below. The second cause, that is the overheating of a portion of the stem, is generally a consequence of an unsatisfactory design of the exhaust pockets or of the valve guides, in the first case causing heat to be delivered to the stem of the valve, and in the second case preventing the proper flow of heat from the head. The third cause, which is the existence of a constriction in the neck, causes stretching in consequence of the production of an action similar to that of cause (2). The mass of metal here is less than at either side, and consequently becomes heated more rapidly. The cross-sectional area for conduction of heat from the head is also smaller, and consequently this part become heated.

Occasionally, stretching of the stem is caused by excessive scaling. This action produces other effects, however, and is dealt with separately.

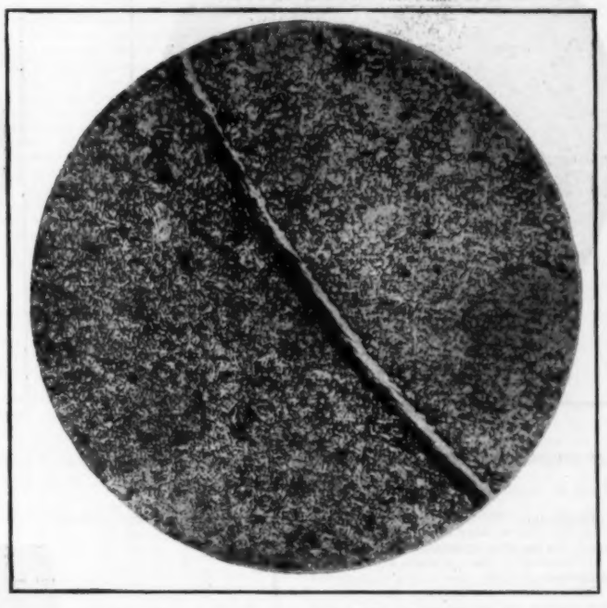


FIG. 2. PHOTOMICROGRAPH OF FLAW IN VALVE HEAD.

2. Distortion of the head of the valve may arise from various causes. In one engine a very serious number of failures occurred through the distortion of the head, which were traced to the fact that the stampings which were used had not been properly heat-treated. The valve stampings had been machined without any heat treatment having been performed on the steel after forging. The result was that the valves went into the engine without any of the strains produced by the forging operation having been removed. When the valve became heated in consequence of the running of the engine, these strains were released and the valve warped appreciably, sufficiently so to prevent it seating properly. When once the valves did not seat properly their destruction was only a matter of time. It is essential that valve forgings which are likely to be heated to any high temperature, and, in fact, all valve forgings, should be heat-treated most carefully, and every care taken to remove the strains produced by forging. This might be done by a simple process of normalising if a suitable steel were employed, but it can be done just as well by hardening and tempering if the tempering is done at a suitably high temperature.

Distortion of the head of a valve may occur and

* Paper read before the Institution of Automobile Engineers, November 5, 1919.

produce failure, even if the forging has been properly heat-treated before being put into the engine. If the valve is so placed that the head is unequally heated, then this inequality of temperature may have a distorting effect. Sometimes this trouble can be overcome by utilising a desi n which allows the valve to rotate during running. This may or may not have the desired effect, but it generally improves matters.

A further cause of distortion in the head of the valve is the undue or exceptional softening of the steel during running. If this happens, the valve may easily be pulled out of shape by hammering against the seating and tend to be pulled through by the spring. The author has examined cases in which this distortion has taken place to a considerable extent in consequence of the utilisation of too weak a steel (or the development of too high a temperature), the distortion taking the form of a reduction of diameter across the head by an action which resembles the closing of an umbrella. The causes of the softening are twofold, either the employment of a steel which is not sufficiently strong at high temperatures, or else the utilisation of a design in which there is not sufficient metal in the valve head.

3. Cracks in the valve face are a fairly prolific source of trouble. This should be considered definitely as a very easy to arrange, and therefore it is not uncommon either for the foot of the valve to be softer than is intended, or else for it to have been hardened so drastically that it cracks. To avoid this trouble it is necessary to use a steel which hardens very simply or else to make such a design that the valve foot can be fitted with a suitable screwed cap.

6. Burning out of the head of the valve is a fairly vague expression, although it is one which is used very considerably. Burning out may be due to several causes, and as stated above these are not entirely attributable to the steel. It is much more nearly true to say that in all cases where burning out occurs, the engine has been running badly. Pre-ignition or bad timing is a very frequent cause of burning out, as explained above (Figs. 3 and 4, below).

Apart, however, from the questions of the running of the engine, other conditions may enter into the burning out of the valves. One of the principal causes is the oxidisation or scaling of the steel, dealt with in the next paragraph. Cracks in the valve face are a very prolific source of burning out, and they have been described above. If a valve does not seat properly, then burning out is almost certain to result. There is such a considerable flow of hot gases round the valve that the property of the temperature to which the steel is heated, and is also a characteristic function of the steel itself. Some steels will scale much more easily than others, and it may be taken as a fairly general rule that the higher the temperature the more easily does a steel become oxidised. If a valve becomes scaled at any point there is a considerable likelihood that the scale may become detached in consequence of the vibration in the valve due to running, and then the scale falls away. If it happens to fall on a part which is already strongly heated, it may assist in the further scaling of the valve at that particular point. If the scaling occurs anywhere near to the face of the valve, or if any scale happens to drop on this part, then an action is set up here which causes the valve to seat badly, and therefore allows the exhaust gases to escape round the valve at this point. Bad seating also means that the valve cannot cool itself in the proper manner, and therefore the temperature of the head becomes higher than was expected. In either case the amount of scaling rapidly increases until the valve head is quite eaten away near to the danger point.

8. Breaking of the head or neck due to self-hardening. Various cases have been known in which a valve has worked satisfactorily for a certain length of time, and then has failed by the breaking up of the head, or the

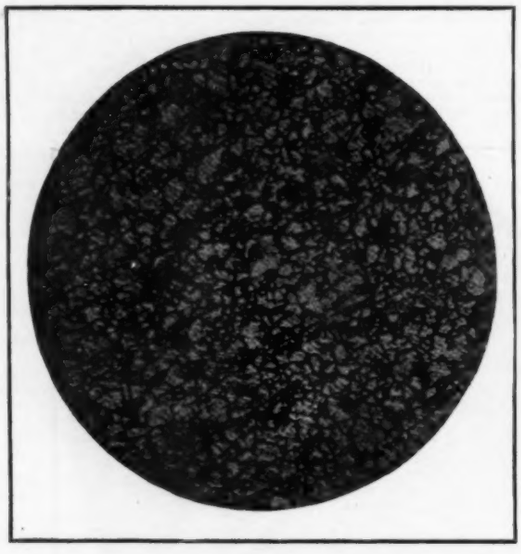


FIG. 3.

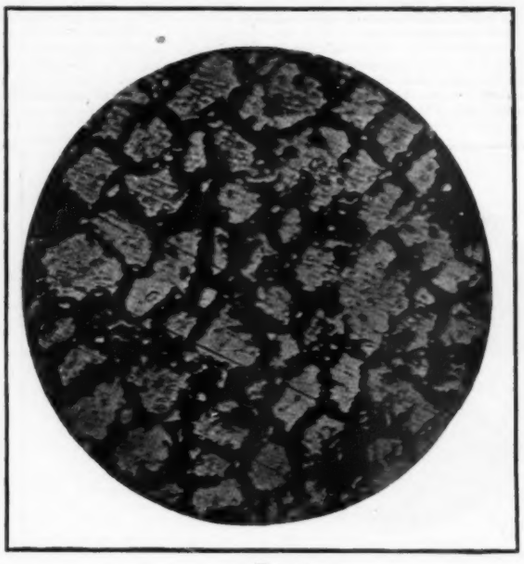


FIG. 4.

PHOTOMICROGRAPHS SHOWING STRUCTURE OF HIGH TUNGSTEN STEEL VALVE AFTER BURNING OUT—INDICATING HIGH TEMPERATURE ATTAINED—FIG. 3 AT 135 AND FIG. 4 AT 470 DIAMETERS MAGNIFICATION.

steel fault. The cracks may have been present in the steel bar from which the valves were made, or they may have been produced during the operation of stamping the valve. They are frequently very minute, and require most careful examination if they are to be discovered (see Fig. 1, page 799).

Occasionally the cracks are produced in the valve head during actual running. If an air-hardening steel is used there is always a possibility that the temperature of the steel will rise above its hardening temperature when in the engine, and on cooling small cracks may be set up along the face.

From whatever cause the cracks may come they are dangerous, because even the most minute crack will allow some of the compressed gas to percolate into it, and this sets up a destructive action on the steel. As a result of this action it is not uncommon to find a chunk of the valve head bitten right out, the gases having eaten away into two contiguous cracks which have then joined up, with the result that a portion of a valve has been blown right out (Fig. 2, page 799).

4. Excessive wear of the valve stem occurs more commonly in rotary engines than in any others. This action must necessarily be provided against by the selection of a suitable steel. In general, the stem of a valve (at any rate, over the greater part of its length) does not become heated to a higher temperature than 400 deg. C., and there should be no difficulty in choosing a steel which will wear satisfactorily under these conditions, as very little softening of a steel takes place up to the temperature attained by the stems.

5. Excessive wear of the valve foot very often occurs. This trouble is usually found in those valves in which the blow of the tappet is delivered directly on to the foot of the valve or in which the cam acts directly on the valve stem, no cap being fitted to take the blows or the wipe. In valves which are designed in this way it is usual to attempt to provide against the excessive wear by completely hardening the valve on the foot only. This necessarily requires the use of a suitable steel. It may be said here and now that no valve should be put into an engine in which the head has not been fairly thoroughly softened, and hence in a valve in which the wear has to be taken by the foot it is necessary to have one short piece of steel in two different conditions of hardness at the opposite ends. This condition of affairs is not always

FIG. 5. PHOTOGRAPH OF VALVE WHICH FAILED AS A RESULT OF EXCESSIVE SCALING IN THE NECK.

temperature attained is higher than it should be, and, in addition to this, the valve does not come into proper metallic contact with the seating, and is therefore unable to cool itself properly.

7. As stated above scaling of the valve is one of the causes which leads to trouble. Scaling may occur in various parts, but it most generally takes place either on the back surface of the head, or else on the neck or lower part of the stem (Fig. 5, above). Burning out is a snapping of the neck of the valve. This is found to happen most frequently when starting up an engine which has previously run and then gone cold. Also the valve which most usually fails in this manner is one which is manufactured from air hardening nickel chromium steel. The valves during the first running have been heated to a temperature greater than, say, 750 deg. C., and then have been allowed to cool down. As a result of this cooling, the valves have hardened to such a degree that the maximum strength of the steel has reached a figure of possibly 100 tons per square inch. This hardening is generally accompanied by the production of a certain amount of brittleness. Cracks also may have been produced during the process of hardening during cooling in consequence of slight irregularities of the surface. When the engine is restarted, the brittle valve breaks in the head or else the head falls right off.

To obviate this trouble it is essential that a steel should be chosen which does not harden when cooled in air from the temperature attained by the valve during the running of the engine into which it is put.

Properties of the Ideal Valve Steel.—The above discussion has shown the various ways in which the valves fail, and as a consequence has brought out certain properties which should be possessed by the steel which is to be used for the manufacture of the valves of petrol engines. To produce a perfect valve, it is obvious that there are a very considerable number of properties which the steel should have, and it is difficult to expect that all these properties will be found in one and the same steel. The following list shows the properties which the steel should possess :—

1. The greatest possible strength at high temperatures.
2. The highest possible notched bar value.
3. The capacity of being forged easily.
4. The capacity of being manufactured free from cracks, whether these arise in the manufacture of the steel bar or whether they are produced during the forging of the steel.
5. The capacity of being heat-treated easily, regularly, and reliably.
6. The least possible tendency to scale, and if scaling does occur, the scale should be as adherent as possible.
7. The ability to retain its original physical properties after frequent heatings to high temperatures followed by cooling to normal temperature, also after being heated

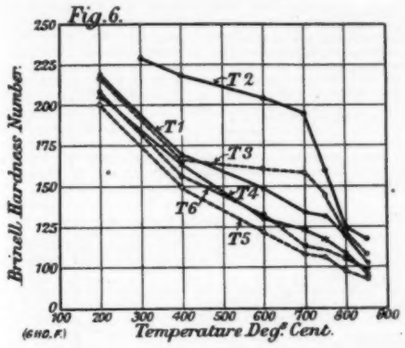
to an elevated temperature for a considerable length of time.

8. No liability to harden when cooled in air from the temperature which it will attain when used normally as a valve in an engine.

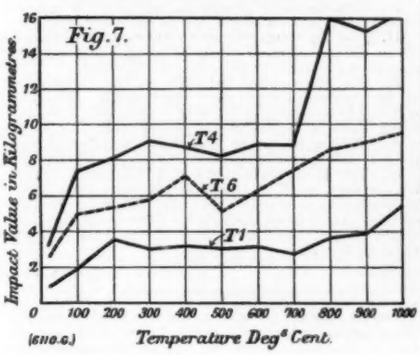
9. The capacity of being heat-treated after forging so that it is free from strains liable to produce distortion.

10. Sufficient hardness to withstand excessive wear in the stem.

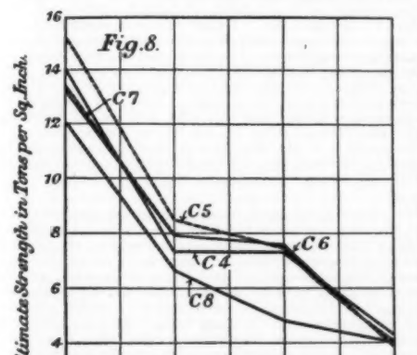
11. The capacity of being hardened at the foot of the stem with considerable ease if necessary.



BRINELL HARDNESS TESTS ON HIGH TUNGSTEN STEEL AT HIGH TEMPERATURES.



CURVES SHOWING NOTCHED BAR VALUES OF HIGH TUNGSTEN STEELS AT HIGH TEMPERATURES.



CURVES SHOWING TENSILE STRENGTH OF HIGH CHROMIUM STEELS AT HIGH TEMPERATURES.

12. The capacity of being machined easily and satisfactorily by ordinary methods.

Various Proposed Steels.—It is evident from the above list that no particular steel will possess all the desirable properties of the ideal valve steel to the maximum degree. It is obvious, therefore, that the various steels which have been used in the past have been selected upon the basis either that they possess all the properties to a reasonable extent, or else that they possess certain properties in a very marked degree. Amongst the steels which have been employed and probably still are employed in various engines for valves are the following :—

1. Tungsten steel of various compositions, ranging from 10 per cent. to 18 per cent. tungsten, and from 0·2 per cent. to 0·7 per cent. of carbon.

2. High chromium steels of different kinds, ranging from 7 per cent. to 14 per cent. of chromium, from 0·25 per cent. to 1 per cent. of carbon, together with varying proportions of silicon, nickel and cobalt.

3. 25 per cent. nickel steel.

4. Steels containing about 3 per cent. to 5 per cent. of nickel together with chromium varying from 0 per cent. to 1·5 per cent., and carbon from 0·15 per cent. to 0·65 per cent.

5. Ordinary plain carbon steels.

In Table I are shown the compositions of the various

TABLE I.

Steel.	Carbon.	Nickel.	Chromium.	Tungsten.	Cobalt.	Vanadium.
a	0·65	—	3·5	17·0	—	0·8
b	0·60	—	3·5	14·0	—	0·8
c	0·25	—	3·5	11·5	—	—
d	0·30	25·0	—	—	—	—
e	0·35	—	13·0	—	—	—
f	0·70	—	11·0	—	—	—
g	0·80	—	7·0	—	—	—
h	0·35	3·0	—	—	—	—
j	0·60	3·0	—	—	—	—
k	0·30	3·75	1·0	—	—	—
l	0·30	4·25	1·4	—	—	—
m	0·15	3·75	1·0	—	—	—
n	0·10	5·8	0·25	—	—	—
o	0·30	—	—	—	—	—
p	1·0	0·5	11·5	—	4·0	—

steels corresponding to the different groups given above, and it will be seen at once, if the foregoing sections are considered, that there can be no real reason for the use of such a very large variety of valve steels. It is desirable, therefore, to submit all these steels to the various tests called for by the list of properties of the ideal valve steel in order to see how nearly each one of them possesses these ideal properties, and therefore how far it is justifiable to employ that steel for valves.

In order to be able to evaluate the various steels, a large number of tests have been carried out upon steels complying with practically every variation of composition in the above list. These tests have been carried out at high temperatures, the temperatures being chosen to cover the working range of temperatures attained by the valves during running. These tests have been mainly tensile tests, but notched bar tests also have been carried out at high temperatures, and in some cases Brinell hardness tests. An examination has also been made of the extent and manner in which the different steels scale. The results of these tests are shown in the following tables.

Tungsten Steels.—Tests have been made to determine the effect upon the properties of these steels at high temperatures of variations in the content of the critical elements, i.e., carbon and tungsten, as shown in Table II. The tests include tensile tests, notched bar tests, and Brinell hardness tests.

TABLE II.—*Chemical Composition of Steel used.*

Steel.	Carbon.	Manganese.	Tungsten.	Chromium.	Vanadium.
T 1	0·60	0·08	17·44	3·64	1·00
T 2	0·60	0·09	16·37	3·86	0·06
T 3	0·67	0·09	13·56	3·70	0·10
T 4	0·45	0·07	13·08	3·62	—
T 5	0·45	0·08	15·73	3·75	—
T 6	0·47	0·07	12·68	3·62	0·80
T 7	0·71	0·05	17·30	3·86	0·75
T 8	0·43	0·37	12·10	3·19	—

All the steels were tested at normal temperatures and at the high temperatures, after being refined at 950 deg. C. and tempered (or softened) at 800 deg. C. The results are shown in Tables III to VI and Figs. 6 and 7.

TABLE III.—*Tensile Tests at Ordinary Temperatures.*

Steel.	Yield Point.	Ultimate Strength.	Elongation.	Reduction of Area.
	tons per sq. in.	tons per sq. in.	per cent.	per cent.
T 1	40·2	48·6	18·0	30·8
T 2	42·1	52·5	18·0	24·6
T 3	44·6	50·9	24·0	38·6
T 4	39·9	47·8	25·0	45·3
T 5	39·0	44·6	30·0	59·4
T 6	39·6	45·5	29·0	49·4
T 7	39·4	58·4	19·0	19·0
T 8	24·7	50·0	26·0	53·0

TABLE IV.—*Ultimate Strengths, tons per sq. in. at High Temperatures.*

Steel.	Temperature of Specimen, Deg. C.						
	650	700	750	800	860	900	950
T 1	—	17·7	—	—	—	8·3	—
T 2	—	17·0	—	—	—	8·95	—
T 3	—	15·9	—	—	—	7·65	—
T 4	—	14·75	—	—	—	7·45	—
T 5	—	15·5	—	—	—	6·3	—
T 6	—	16·85	—	—	—	7·25	—
T 7	24·7	—	13·2	10·3	11·1	8·8	6·6
T 8	20·1	—	10·0	7·1	9·6	8·2	—

TABLE V (see Fig. 6).—*Brinell Hardness Tests at High Temperatures.*

Steel.	Brinell Number of Sample at Temperature Deg. C.							
	200	300	400	600	700	750	800	850
T 1	193	—	170	149	131	129	119	101
T 2	—	228	217	205	193	161	124	114
T 3	219	—	166	162	158	143	116	109
T 4	207	—	164	129	123	115	109	95
T 5	200	—	149	121	110	107	98	92
T 6	209	—	156	128	113	111	107	98

TABLE VI (see Fig. 7).—*Notched Bar Values in Kilogrammetres at High Temperatures.*

Temperature of Sample, Deg. C.	Steel.					
	T 1.	T 2.	T 3.	T 4.	T 5.	T 6.
18	0·91	0·88	1·16	3·14	1·42	2·54
100	1·95	1·4	2·0	7·4	4·3	5·0
200	3·60	2·4	2·95	8·1	8·0	5·5
300	3·0	3·2	2·80	9·1	9·0	5·8
400	3·20	2·9	3·20	8·7	9·3	7·1
500	3·00	3·9	2·95	8·2	8·0	5·2
600	3·09	3·1	3·4	8·9	7·5	6·3
700	2·67	3·3	3·3	8·8	8·0	7·5
800	3·62	2·9	4·2	16·0	9·2	8·6
900	3·92	6·0	7·5	15·8	9·5	9·0
1,000	5·41	7·8	8·8	16·9	8·1	9·5

Chromium Steels.—Tests have been made here to find the effect upon the mechanical properties of the steels at ordinary and at high temperatures of variations of composition as regards carbon, chromium, cobalt, silicon, and nickel, shown in Table VII, and the results of the tests are given in Tables VIII to XI and Figs. 8 and 9,

TABLE VII.—*Chemical Compositions of Steels Used.*

Steel.	Carbon.	Silicon.	Nickel.	Chromium.	Cobalt.
C 1	0·37	0·25	0·15	12·37	—
C 2	1·04	0·15	—	10·42	—
C 3	1·12	0·85	0·50	11·35	3·90
C 4	0·96	0·17	0·45	13·1	—
C 5	1·08	0·17	0·50	13·1	—
C 6	1·18	0·10	0·45	13·1	—
C 7	1·42	0·35	0·44	13·1	—
C 8	0·36	0·16	0·23	11·2	—
C 9	0·54	0·14	0·43	6·3	—
C 10	0·55	0·75	0·50	7·1	—
C 11	0·56	0·17	3·08	6·6	—
C 12	1·09	0·19	0·42	6·3	—
C 13	1·08	0·56	0·51	6·7	—
C 14	1·11	0·19	2·96	5·8	—

The heat-treatments given to the steels before testing were as follows :—

Steels C1 and C2—hardened in air from 880 deg. C., tempered at 700 deg. C.

Steel C3—hardened in air from 1,000 deg. C., tempered at 800 deg. C.

Steels C4 to C8—hardened in air from 900 deg. C., tempered at 700 deg. C.

Steels C9 to C14—hardened in oil from 820 deg. C., tempered at 650 deg. C.

TABLE VIII.—*Tests at Ordinary Temperature.*

Steel.	Yield Point.	Ultimate Strength.	Elongation.	Reduction of Area.
	tons per sq. in.	tons per sq. in.	per cent.	per cent.
C 1	22·2	43·4	30·0	65·0
C 2	37·3	66·5	15·0	32·0
C 3	35·1	54·3	32·0	32·0
C 4	35·6	53·8	18·5	36·4
C 5	38·0	56·6	17·5	29·1
C 6	40·8	56·2	16·5	30·6
C 7	40·8	59·7	10·0	18·3
C 8	32·0	43·0	21·0	48·0
C 9	59·5	65·6	15·7	54·6
C 10	57·5	66·3	18·6	55·0
C 11	58·1	67·8	17·2	53·9
C 12	72·5	77·8	11·4	28·6
C 13	69·5	78·5	10·0	22·5
C 14	56·6	63·8	14·3	56·5

Three per Cent. Nickel Steel Group.—In this group are steels with about 3 per cent. of nickel, together with various percentages of carbon and chromium (see Table XII). A 3 per cent. chromium steel is also included. The results of the tests are given in Table XIII.

Heat Treatment given to the Steel before Testing.—The steel was normalised at 850 deg. C. before testing.

A close examination of the test results is given in Appendix 1.

Scaling Tests.—The results of the scaling tests are set out in diagrammatic form in the curves given in Fig. 10.

Consideration of Experimental Results.—The facts which emerge from the experimental results shown above appear to be as follows :—

1. That the principal factor in deciding the properties of a steel at high temperatures is its type. By this is meant that all the tungsten steels have fairly similar properties, whilst all the chromium steels have fairly

similar properties amongst themselves, but different from the tungsten steels, whilst the nickel chromium steels have properties characteristic of themselves, but different from any of the others.

2. That there is a considerable similarity as regards mechanical properties at high temperatures between those steels which have a similar constitution. The high tungsten steels possess in most cases a structure which consists of a solid solution of iron, tungsten and carbon, together with some free carbides. The chromium steels do not possess this structure unless the carbon content rises beyond about 0·7 per cent. When that carbon content is reached the steels possess a structure which consists of solid solution more or less completely decomposed (according to the heat-treatment the steel has received), together with free carbides. The result is that the high carbon chromium steels have properties distinctly similar to the high tungsten steels.

3. That amongst the different steels in any type, variations in composition have a distinct effect upon the mechanical properties at high temperatures. This is particularly true of the high tungsten and the high chromium steels, in which a variation in carbon content produces a very marked effect upon the tensile strength or upon the notched bar value. This variation is also noticeable in the 3 per cent. nickel and 3 per cent. chromium steels, but is not so marked as in the steels containing a larger proportion of alloying elements. In these steels a variation of 0·2 per cent. of carbon will have a greater effect upon the strength than a variation of 5 per cent. tungsten or even 7 per cent. of chromium.

4. That the tungsten steels with the high percentages of carbon (*i.e.*, about 0·6 per cent.) have the greatest tensile strength at high temperatures. This strength is most nearly rivalled by that of the high chromium steels containing a high percentage of carbon.

5. That steel containing a high percentage of chromium with a lower percentage of carbon (*e.g.*, stainless steel) is distinctly weaker than either the high tungsten steels or the steel containing a similar proportion of chromium with high carbon.

6. That the plain nickel or nickel chromium steels are quite weak at high temperatures as compared with the other steels. Variations in composition amongst these steels have apparently very little effect.

7. That the influence of vanadium on the properties of the tungsten steels at high temperatures appears to be negligible.

8. That steels containing cobalt appear to possess no superior properties at high temperatures over those free from cobalt.

9. That the high chromium steels present the greatest resistance to scaling at high temperatures of any of the steels. Those of the "stainless" type give a very high resistance, whilst those containing about 7 per cent. of chromium give a very fair resistance, though not quite so good as that of the stainless steels. In the latter case, however, the scale is more adherent than in the case of the stainless steel type.

10. That the nickel chromium steels scale to a greater extent than do the steels of any of the other types.

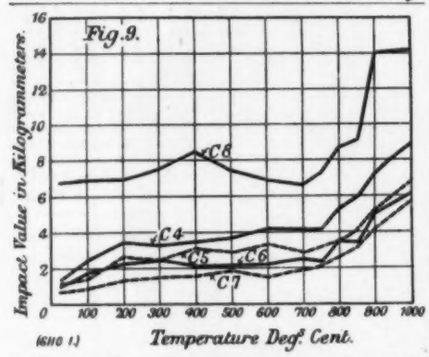
11. That the tungsten steels scale comparatively little up to temperatures of about 850 deg. C., but beyond that they are liable to scale very considerably.

12. That the notched bar values of the various steels at high temperatures vary considerably, but are a reasonable reflection of the tensile strength of the steel, being more or less inversely proportional to this property. The notched bar tests show the effect of variations in carbon content quite as markedly as do the tensile tests, those steels containing a high percentage of carbon having very much smaller notched bar values even at high temperatures than those with a low percentage of carbon. In all cases the notched bar value is very much higher for steel at elevated temperatures than it is when the steel is cold.

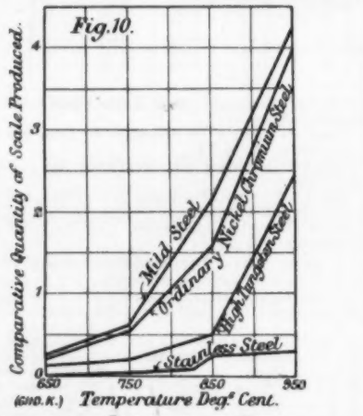
(To be continued.)

TABLE IX.—*Ultimate Strengths, Tons per Square Inch at High Temperatures* (see Fig. 8).

Steel.	Temperature of Specimen, Deg. C.								
	650	700	750	800	850	900	920	950	1,000
C 1	13·6	—	7·0	6·5	8·6	6·5	6·7	5·2	—
C 2	21·5	—	10·0	7·5	9·6	7·5	—	6·5	—
C 3	21·0	—	10·5	7·0	9·6	8·8	—	6·5	—
C 4	—	14·0	—	7·3	—	7·3	—	—	4·1
C 5	—	15·2	—	8·5	—	7·4	—	—	4·0
C 6	—	13·2	—	7·9	—	7·5	—	—	3·8
C 7	—	13·3	—	7·9	—	7·6	—	—	3·9
C 8	—	12·1	—	6·6	—	4·8	—	—	4·0
C 9	—	17·0	—	—	—	7·0	—	—	—
C 10	—	14·9	—	—	—	7·2	—	—	—
C 11	—	17·8	—	—	—	7·6	—	—	—
C 12	—	18·4	—	—	—	7·5	—	—	—
C 13	—	21·0	—	—	—	7·3	—	—	—
C 14	—	18·2	—	—	—	5·6	—	—	—



CURVES SHOWING NOTCHED BAR VALUES OF HIGH CHROMIUM STEELS AT HIGH TEMPERATURES.



DIAGRAMMATIC INDICATION OF DEGREE OF SCALING OF DIFFERENT STEELS.

TABLE X.—*Notched Bar Values in Kilogrammetres at different Temperatures* (see Fig. 9).

Temperature of Specimen, Deg. C.	Steel.				
	C 4.	C 5.	C 6.	C 7.	C 8.
18	1·27	1·12	0·98	0·71	6·8
100	2·41	1·43	1·73	0·87	6·92
200	3·52	2·76	2·23	1·34	6·92
300	3·23	2·45	2·45	1·50	7·50
400	3·42	3·04	2·02	1·50	8·43
500	3·62	2·81	2·06	1·86	7·40
600	4·07	3·33	2·14	1·58	6·92
700	4·02	2·85	2·49	1·86	6·56
750	4·02	3·19	2·27	2·07	7·28
800	5·35	3·46	3·47	2·62	8·68
850	5·93	4·02	3·37	3·09	9·11
900	7·34	5·25	5·03	4·17	14·00
1,000	8·86	6·79	6·09	5·63	14·23

TABLE XI.—*Tensile Tests on Steel* C 8 *at All Temperatures up to* 1,000 *Deg. C.*

Temperature of Specimen, Deg. C.	Yield Point.	Ultimate Strength.	Elongation.	Reduction of Area.
	tons per sq. in.	tons per sq. in.	per cent.	per cent.
18	38·8	48·5	27·5	59·3
100	37·0	43·5	21·0	54·6
200	37·0	44·0	21·0	55·8
300	33·4	39·6	18·5	57·0
400	33·6	39·9	17·5	53·6
450	31·3	34·9	18·5	63·7
500	28·7	29·7	22·0	71·7
600	20·8	24·2	25·0	75·9
700	10·8	12·1	40·0	90·9
800	5·1	6·6	40·5	91·9
850	4·7	6·6	40·5	92·4
900	3·8	4·8	41·0	65·8
970	2·0	4·0	31·5	52·2

TABLE XII.—*Chemical Compositions of Steels Employed.*

Steel.	Carbon.	Manganese.	Nickel.	Chromium.	Vanadium.
N 1	0·28	0·46	2·80	1·34	—
N 2	0·29	0·46	3·90	1·14	—
N 3	0·37	0·44	2·76	0·64	—
N 4	0·24	0·34	4·47	1·02	—
N 5	0·29	0·43	3·22	0·08	—
N 6	0·60	0·95	1·99	0·35	—
N 7	0·35	0·43	—	2·75	—
N 8	0·67	0·51	—	3·13	0·30

Heat-treatments given to the Steels before Testing.

N1—hardened in oil from 820 deg. C. and tempered at 630 deg. C.

N2 (a)—hardened in air from 820 deg. C. and tempered at 600 deg. C.: (b)—hardened in air from 820 deg. C., not tempered.

N3—hardened in oil from 820 deg. C. and tempered at 560 deg. C.

N4—as forged.

N5—hardened in oil from 830 deg. C. and tempered at 600 deg. C.

N6—hardened in oil from 830 deg. C. and tempered at 600 deg. C.

N7—hardened in oil from 830 deg. C. and tempered at 600 deg. C.

N8—hardened in oil from 830 deg. C. and tempered at 600 deg. C.

TABLE XIII.—*Ultimate Strengths, tons per sq. in. at High Temperatures.*

Steel.	Temperature of Specimen, Deg. C.						
	650	700	750	800	850	900	950
N 1	15·9	—	8·5	7·0	5·4	4·6	—
N 2a	14·4	—	8·6	—	5·1	4·2	3·5
N 2b	12·6	—	8·0	—	5·4	4·6	3·4
N 3	15·0	—	9·0	—	5·0	4·5	3·6
N 4	12·8	—	8·4	—	5·7	4·4	3·3
N 5	—	9·4	—	—	—	3·9	—
N 6	—	11·5	—	—	—	4·5	—
N 7	—	8·5	—	—	—	4·2	—
N 8	—	11·7	—	—	—	4·9	—

TABLE XIV.

Synopsis of results of tensile tests at high temperatures—giving the results of the more representative steels.

Ultimate Strengths, tons per sq. in. at High Temperatures.

Steel.	Temperature of Specimen, Deg. C.				
	700	800	850	900	950
Plain carbon	—	—	—	—	—
High tungsten, high carbon	17·7	10·3	11·1	8·8	6·0
High tungsten, low carbon	15·5	—	—	6·3	—
Low tungsten, high carbon	15·9	—	—	7·6	—
Low tungsten, low carbon	14·7	7·1	9·6	7·4	—
High chromium, low carbon	12·1	6·6	—	4·8	4·0*
High chromium, high carbon	15·1	8·5	9·6	7·5	6·5
Low chromium, low carbon	17·0	—	—	7·05	—
Low chromium, high carbon	18·5	—	—	7·5	—
3 per cent. Nickel, low carbon	9·4	—	—	3·9	—
3 per cent. nickel, high carbon	11·5	—	—	4·5	—
3 per cent. chromium, low carbon	8·5	—	—	4·2	—
3 per cent. chromium, high carbon	11·7	—	—	4·9	—
Nickel chromium	10·5	7·0	5·1	4·5	3·0

* Temperature of specimen, 875 deg. C.

TOUGH RUBBER-COVERED CABLE.—The General Electric Company, Limited, of 67, Queen Victoria-street, E.C. 4, supplied during the war for Government purposes, many thousand miles of tough rubber-covered electric cable, from the Pirelli-General Cable Works, Southampton. The falling-off in the demands of the Army, Navy, Ministry of Munitions, &c., now makes large qualities of such cable available for delivery by the firm to private users. Tough rubber-covered cable has become of considerable importance in industrial work during recent years. The conductors in such cable are insulated with pure and vulcanised india-rubber, and the whole is then sheathed with tough rubber which is resistant to water, oil, alkali and acid, and is capable of standing a great deal of rough mechanical handling. In the wiring rules of the Institution of Electrical Engineers it is provided that cable of this class may be used for wiring without the employment of either conduit or wood casing.

GERMAN ATTEMPT TO SOLVE EXCHANGE DIFFICULTIES.—One method employed by Germans to maintain the value of the German mark and prevent its exportation to neighbouring countries, where the rate of exchange would militate against the business interests of the present confederation, has been observed in the Netherlands. It consists, says *The Board of Trade Journal*, of the continued "turning over" of manufactured articles for goods of higher value. For example, Germany at the present time is greatly in need of boots and shoes, but has not the hides to employ for the purpose. Traders solve this by placing a contract in the Netherlands for a number of untanned hides, take them to Geramn tanneries and convert them into leather, returning them to the Netherlands with a certain number deducted as payment for the tanning. The German interests then make a further contract with the owners of the now tanned leathers to return these to Germany, where they will be converted into boots and shoes. This done, the manufactured product is once more sent to Holland, the process of deducting a certain quantity as payment having been repeated. The amount of boots and shoes thus received is practically of no importance, and to be able to return to Germany the whole of its manufactures it is necessary that an additional step be taken, which is done by bartering the stock in the hands of the Dutch merchants for some other German manufactured product, such as dyestuffs or medicines. By this return to primitive trading methods Germany is enabled to sell its products and to purchase those of which it is in the most need without the exchange of any money—a practice well calculated to sustain its credit in the money world, as it permits the price of these goods to be calculated upon their real value.

FUTURE TRAFFIC DEVELOPMENTS.

1. *Provision of New Roads.* 2. *Road Finance.* 3. *Provision of New Transport Services.**

By W. REES JEFFREYS.

ROADS and road policy and the relation of both towards the whole problem of national transport need to be reconsidered as a result of passing into law last session of the Ministry of Transport Act.

Either directly or indirectly the new Minister, through his financial powers, will be able to control during the next two years the development and extension of all forms of road transport, harbours, docks or piers, and canals. For all practical purposes his powers are unlimited to check or to encourage transport development in this country. He will be able to determine the direction that any development shall take.

Although it is true that the House of Commons made provision in the Act for the appointment of certain committees, these bodies are advisory only.

It will be noted that the Minister of Transport is required by the Act to consult the Roads Committee in regard to roads classification for the purposes of advances for construction, improvement and maintenance.

What may we expect from the Roads Committee? I am none too hopeful that the committee will play a very important part in the development of road transport. Its usefulness will depend, however, upon three factors: (1) The attitude of the Minister and his department towards the committee; (2) the constitution of the committee; and (3) the capacity of the man who is elected chairman of the committee.

As regards (1): Is it the intention of the Minister to make the committee part of the ordinary machinery of the department? That is to say, will he: (*a*) cause papers relating to current business to be referred to it? and (*b*) permit the responsible officials of the Ministry to attend the committee's sittings and take part in its discussions? It will be quite easy for the Minister to freeze out the committee if he so desires, by the simple expedient of leaving it to its own devices.

One of the great weaknesses of the committee arises from the fact that it is a body of divided interests. One-half of its members are representatives of road authorities, and the other half represent the road users. The road authorities will not always see eye to eye on the same questions, as the interests of county councils, county boroughs and district councils are not always identical. Scottish and Irish representatives will sit upon the committee, and their standpoint will not be the same as that of the English representatives. On the users' side there will be the interests of the light car, the heavy car and the horse owners, and here again the various points of view are different and sometimes conflicting. It will be difficult for a body so composed and meeting occasionally to agree upon a united policy on questions of practical administration. If sectional views prevail the committee will not carry much weight with the Minister nor will it earn the respect of the House of Commons and the public.

As against these considerations, if the committee succeeds in discovering a chairman who is sufficiently strong and able to command the respect of the Ministry and to carry his colleagues with him and induce them to work together, a more favourable position may arise.

SECTION I.—THE PROVISION OF NEW ROADS.

Large powers for the construction of new roads were conferred upon the Road Board by the Development and Road Improvement Funds Act, 1909. With the passing of the new Act all the Road Board's powers and duties were transferred to the Ministry of Transport. The latter will be able, therefore, to construct and maintain new roads itself, and/or make advances to highway authorities for the same purposes. Under the Development and Road Improvement Funds Act the Road Board was authorised to acquire not only the land actually required for a new road, but in addition, "land on either side of the proposed road within 220 yards from the middle" of that road, in order that it might apply the principle of "betterment" and thereby reduce the cost of the road to the public. That power, which was never exercised by the Road Board, may be acted upon by the Ministry of Transport. The Board could also borrow on the security of the Road Improvement Fund.

Further, new roads can be laid out and constituted under the provisions of the Housing, Town Planning, &c., Acts of 1909 and 1919. The latter measure contains a provision, Section 42 (ii), enabling local authorities desirous of acting jointly in the preparation or adoption of a town-planning scheme to appoint joint committees for the purpose. The preparation of town-planning schemes is under Section 46 of the Act to be obligatory upon urban authorities in three years' time.

Notwithstanding the powers in the Development and Road Improvement Funds Act and in the Town Planning Acts, it is doubtful if any progress will be made in the building of new roads passing through the areas of several local authorities, to relieve the traffic on the existing arterial roads. The need for such roads is admitted. The important and valuable Arterial Road Conferences of London, 1913–14, were unanimous as to the need for such roads through the suburbs and undeveloped areas of Greater London, and drew up definite schemes. No practical action has been taken to give effect to their reports. As we have already seen, nothing was done by the Road Board itself to build new roads, and during the nine years in which the first Town Planning Act has been in operation only one city has made any real progress in providing for new and wide approach roads under that measure, namely, the City of Birmingham. Why, in spite of the admitted need, is nothing done? The answer is two-fold: (1) The smallness of the local governing unit, and (2) the difficulties of finance.

It is impossible to get a multitude of existing road authorities to combine to carry out any radical scheme of new road construction. Apart from other matters, they never will agree upon the question of the distribution of the cost.

In these circumstances the local authorities and the public look to the Minister of Transport to come in and take the initiative, provide a large part of the funds, and do the work. But is the Ministry of Transport likely to do what the Road Board has failed to do? I doubt it. For one reason, I do not see how the funds which will be placed at the disposal of the Ministry of Transport will permit new road construction on a large scale. These funds will be absorbed in—(*a*) the maintenance grant; and (*b*) small local improvements in which the local authorities are more immediately interested.

What hope do the Town Planning Acts provide? It is possible under those Acts to lay down the lines of new roads and conserve the land so that they can be built as opportunity arises and financial considerations permit. That should at once be done for the new roads recommended by the London Arterial Roads Conferences. But here there will be a division of duties between the Ministry of Transport and the Ministry of Health, which latter is the body entrusted with carrying out the Housing and Town Planning Acts. Much could be done in planning out new roads if the two departments would act together, but the experience of the past shows that it is as difficult to secure co-operation between two Government departments as it is to obtain joint action by two adjacent local authorities.

A practical proposal that arises out of this section of the paper is that this Congress should use its influence to induce the two departments to act together so that the Ministry of Transport, working through the Ministry of Health, will give financial assistance to local authorities to prepare joint town planning schemes in which the line of future arterial roads shall be laid down, and that the Ministry of Transport shall guarantee the local authorities against any claims which may be made against them by land and property owners in respect of worsement, arising from losses caused by interference with development. Further, it is suggested that the Ministry of Transport should pay (1) a large proportion of the cost of new arterial roads through land which has no building value; (2) the entire cost of new bridges over railways or streams; and (3) should advance the money free of interest to the local authorities for the construction of roads through areas which are not ripe for building, against the time when they would be repaid the cost of the roads up to bye-law width by the owners of adjoining property.

The only other practical alternative is to set up regional committees with power to combine areas and levy rates. The alternative plan has been embodied in a draft measure entitled "The London and Home Counties Development, Housing and Traffic Authority Bill," which outlines the powers and duties of such a body for London and the Home Counties. The scheme may be applied to developing areas throughout the kingdom, and its object is to secure the proper and co-ordinated industrial and residential development within such areas, improve traffic facilities and administer grants.

Such a committee would be able to surmount the administrative difficulties which inevitably arise when a large number of small authorities attempt to solve general problems affecting a wide area. Regional planning would become a comparatively simple matter if the country were divided into, say, 20 or 30 large districts each under the jurisdiction of a representative authority empowered to prepare a scheme to which all future plans of development should conform. With the advent of motor transit, road problems became a subject of regional and national, rather than local, concern. But roads and road traffic are so closely related to other public services that these again, cannot be considered alone. The provision of adequate housing accommodation is obviously affected by problems of communication, and must be dealt with in conjunction, and that can only be done by an authority exercising jurisdiction over the widest possible area consistent with efficient and economical administration. Local planning would be simplified and could readily be carried out by the existing authorities.

SECTION II.—ROAD FINANCE.

In 1914–15—the last normal year—the cost of the roads in England and Wales was about 17,500,000*l.* It may be roughly assumed that of that total 1,500,000*l.* was paid for out of the Exchequer contribution account, and 750,000*l.* by the Road Board, leaving a balance of 15,250,000*l.* paid for out of rates. Persistent and constant pressure has been exercised upon the Government with the object of increasing the proportion paid out of Imperial taxation in order to reduce the amount which has to be found by the ratepayers. In the new Transport Act power is given the Transport Minister to classify roads and make grants towards maintenance. The Road Board had no power to make grants towards maintenance. The Minister has to proceed to classify the roads, and the Act lays upon him the obligation to consult the Roads Committee in regard to this matter.

During the passage of the Transport Bill through Parliament the Minister was asked whether he proposed to classify roads and make contributions to road maintenance in accordance with the recommendation of the Departmental Committee on Local Taxation which had been incorporated in the Finance (No. 2) Bill, 1914. To this he replied that he did not wish to be tied by any rigid provisions, for it might well be that the State contributions to maintenance of Class I roads might be as much as 75 per cent. Lord Lytton, in the House of Lords, stated specifically that that would be the future rate of contribution. As the Act stands the Minister is free to adopt any system of classification and distribution he may think fit. He will, however, be always subject to one limitation, and that is the amount of money which the Treasury is willing to give him for that purpose.

Is any of the money that is derived from the taxation of petrol and motor vehicles to be applied towards the maintenance grant? The principle which I assume that motorists—certainly those in this conference—will stand for is that the maintenance grant must represent an additional contribution from the Exchequer and must not be taken out of the Road Improvement Fund. Indeed, any attempt to devote that fund to maintenance purposes would be unauthorised by the statutes affecting it. As the grant will probably take the place of the Exchequer contribution accounts it cannot conceivably be less than the sum, which I have placed at 1,500,000*l.*, already drawn from that source. The local authorities will ask that the figures shall be placed as high as possible, and in all probability will suggest as much as 5,000,000*l.*, or approximately a third of the cost of maintenance. Personally I doubt whether the sum which the Treasury will find for maintenance will exceed 3,000,000*l.*

Whatever the amount available for maintenance grants, whether it be 1,000,000*l.* or 5,000,000*l.*, do they want the money distributed by way of a large grant over a small mileage of roads or by a smaller percentage grant over a larger mileage of roads? For make no mistake, the percentage will govern the classification. The Treasury will fix a figure which in the first year they will not be prepared to exceed having regard to the other claims upon the Imperial Exchequer, and the Minister will have to make his classification and prepare a scheme so that his liabilities will not exceed that amount.

Under the scheme of the Government of 1914 the proposal was that roads should be classified into three groups—first, second and third—and that the first class should receive 50 per cent. of the cost of maintenance, the second class 25 per cent. and the third class nothing. If this principle be adopted it is clear that if the mileage of the first-class roads is fixed high and they receive 50 per cent., and the sum to be divided is 3,000,000*l.*, there will be very little left for second-class roads, and the mileage within this category will be very small indeed. It has been suggested, as I have pointed out, that the contribution to first-class roads shall be fixed as high as 75 per cent., which would have the effect of permitting only a very small percentage of the 152,000 miles of roads in England and Wales to receive any grant at all. Personally, I am inclined to the view that it is desirable that a large mileage of roads should share in the maintenance grant, and for that purpose I would not fix the percentage payable in respect of the first-class roads too high, or make their mileage too big a percentage of the whole.

Below are given two possible tables showing the distribution of a 3,000,000*l.* grant. The figures are rough approximations, but they serve to illustrate what is meant. They are based on the figures for the last normal year, and have accordingly to be increased by the additional cost of material and labour, if it is assumed that in the first after-war year no less a programme of work will be carried out. The Treasury grant would also be proportionately increased.

Scheme A.—Table showing the effect of a classification based on a 3,000,000*l.* grant (pre-war standard) distributed over a small mileage of roads with a high percentage of contribution:—

Class of Roads.	Mileage.	Maintenance Cost.	Percentage Grant.	Amount of Grant.
		£		£
Class I	5,000	2,000,000	75	1,500,000
Class II	20,000	2,400,000	50	1,200,000
Class III	114,000	5,700,000	—	—
County Boroughs and London ..	12,500*	6,000,000	—	300,000
Totals ..	151,500	16,100,000	—	3,000,000
Improvement and other charges outside maintenance ..	—	1,400,000	—	—
Totals ..	151,500	17,500,000	—	3,000,000

* Total mileage of roads and streets. The mileage available for grants if these roads were classified would not exceed 1,250.

Scheme B.—The table showing the effect of a classification based on a 3,000,000*l.* grant (pre-war standard), distributed over a large mileage of roads, but with a lower contribution to the selected roads is given on the next page.

Under the scheme marked "B" outside the county boroughs and London the mileage of roads to receive the grant would be 56,000, or 37 per cent. of the total, as against 25,000, or 16 per cent. under scheme "A." For this reason, and because it secures a fairer distribution, and because more authorities would participate in the grant, I prefer scheme "B" to scheme "A," and commend it to the consideration of the Congress and of the Ministry.

So far the question of roads in the administrative counties has been considered. The next problem that

* Abstract of paper read before the County Councils, Association Congress, on November 26, at the Royal Agricultural Hall, Islington.

arises is: Upon what principles shall the maintenance grant be distributed to roads in the county boroughs and in London. Obviously the same principles cannot be applied in this relation. The conditions are different. The financial burden is different. In the administrative counties through traffic imposes a large additional burden upon the highway authorities. On the main roads through a large county borough the through traffic imposes only a slight additional burden.

Class of Roads.	Mileage.	Maintenance Cost.	Percentage Grant.	Amount of Grant.
		£		£
Class I	16,000	3,520,000	50	1,760,000
Class II	40,000	3,760,000	25	940,000
Class III	83,000	2,820,000	—	—
County Boroughs and London ..	12,500*	6,000,000	—	300,000
Totals ..	151,500	16,100,000	—	3,000,000
Improvement and other charges outside maintenance ..	—	1,400,000	—	—
Totals ..	151,500	17,500,000	—	3,000,000

* Total mileage of roads and streets. The mileage available for grants if these roads were classified would not exceed 1,250.

To give an example. The county boroughs of Coventry and Birmingham are divided by a stretch of about 15 miles of road, mainly rural in character, administered by the Warwickshire County Council. The traffic between Coventry and Birmingham, together with the through traffic on the main Holyhead road, compel the Warwickshire County Council to maintain a road of a much stronger and more expensive character than would be required if that authority were called upon to maintain it only for the traffic of the villages *en route*. Warwickshire can therefore claim, especially in view of the fact that neither Coventry nor Birmingham makes any contribution to the Warwickshire roads, some assistance towards the cost of maintaining the road for the benefit of Coventry and Birmingham and outside traffic generally. When, however, the through traffic using the main Holyhead road gets into Birmingham it travels on a road which for the purposes of Birmingham's own local traffic has had to be strongly constructed and well maintained. The through traffic on the streets of Birmingham imposes only a slight additional burden upon Birmingham, whereas it is the main burden in the County of Warwickshire. The case for giving grants to the county boroughs and London cannot therefore be put upon the same basis as the grant to the administrative counties.

The sound basis is that as the State is now distributing the proceeds of national taxation, some part of those funds should go to London and the county boroughs. The proposal which is most practical is that the roads classified as Class I in the administrative counties shall be joined up through the county boroughs and the connecting links classified as first and second-class roads, as the case may be, and that the county boroughs shall receive in respect of that mileage the same sum per mile as the adjoining administrative counties are receiving on the average in respect of the roads outside the borough. In other words, the connecting links inside the towns should be placed upon the same basis and should receive contributions at the same rate per mile as the county authorities in respect of the roads in the administrative counties.

The maintenance grant, however, will go but a very little way towards solving the problem of the variation of road rates. I have on previous occasions pointed out and given illustrations to show that the mere accident of a parish boundary imposes upon one house as compared with its neighbours, double the rate in respect of highways. There are only two practical solutions of this problem, and neither of them is within sight of realisation at the present time. Government and Parliaments are afraid to tackle the problem of local taxation, and the great report of Lord Balfour's Commission, containing valuable recommendations covering the whole field of rating, still remains unacted upon. That Commission sat in 1896—over twenty years ago.

These two solutions are: (1) To enlarge the area of the unit of local rating and in particular to bring the county boroughs and the administrative counties into one unit for the purposes of the road rate; and (2) to impose a national rate for road purposes on land values and to distribute this rate among the local authorities according to their needs. These solutions, however, raise such large questions that they require treatment in a separate paper. I will defer their consideration to some future occasion.

Section III.—Provision of New Transport Services.

The great railway strike through which we recently passed illumined with the vividness of a lightning flash the possibilities of motor road transport. The course of events which followed the declaration of that strike justified up to the hilt the arguments that were used by some of us during the passage of the Ministry of Transport Bill through Parliament, that roads and road transport must be developed as a vital part of the communications of the country as a whole and must never be subordinated to canals and railways.

One effect of the strike was to demonstrate beyond possibility of dispute that certain types of goods which have hitherto been dealt with by railway can be handled more expeditiously by road.

The improvised London system of food and milk distribution from a great centre like Hyde Park was a wonderful demonstration of the efficiency and utility of motor transport.

During the strike the main thoroughfares of London offered a remarkable object lesson in the comparative efficiency of the tram and the motor 'bus. It was a common experience to see long lines of tram cars held up at congested traffic points, whilst the motor 'bus was picking its way through the traffic, reaching its destination in about half the time that was needed for the progress of the tram car.

I am not going to contend that the tramway has entirely outlived its sphere of usefulness, but I do urge that the tramway and light railway should not be encouraged upon the public roads. It is far better business to build up a motor transport service which can be expanded with the growth of the traffic than to tolerate a bad road carrying an unremunerative tramway or light railway.

Therefore I suggest that the Minister in exercising his powers of creating new transport services should encourage the development of local motor services, particularly in rural areas, in conjunction with the smaller towns and villages of the country. The desirability of such a policy was emphasised in the report of the Rural Transport (Scotland) Committee recently issued. Discussing the utility of the motor vehicles for the conveyance of agricultural produce the committee pointed out that motor transport is possessed of a high degree of flexibility:—

"The lorry can call at farms laying off the main road, whereas in the case of goods carried by a railway through an agricultural district the majority of the farmers would still have to carry them for appreciable distances."

It was further pointed out that rural transport would be possibly better developed by means of an increased number of motor and steam lorries and tractors, "which have the great advantage over railways that they minimise the hauling of goods from the farm to the station and *vice versa*."

Assuming the adoption of the principle it will probably be found desirable that as far as possible, if State subsidies are to be provided at all the Ministry of Transport should give subventions to local authorities and companies rather than attempt to run road transport services itself.

I have referred to one drawback to the development of road transport services in the existing artificial railway rates. There are two other considerations which undoubtedly hamper the normal expansion of motor transport, whether of passengers or goods—(*a*) The provisions of Section 20, Local Government (Emergency Provisions) Act, 1916, relating to the provision of new motor 'bus services; (*b*) the law applicable to extraordinary traffic.

The whole question presses for solution, and should be handled without delay if the country is to take full advantage of road motor traffic for reducing the cost of the production and distribution of goods. And such a reduction there must be if the country is to progress as a commercial nation. Wages have risen and cannot be reduced. The only item in the cost of production on which large savings can be made is the cost of transport.

ON FUTURE DEVELOPMENTS IN PUDDLED IRON MANUFACTURE.*

By J. E. Fletcher, M.I.Mech.E.

In Dr. Desch's illuminating paper on the "Evolution of the Puddling Process," given before this Institute in February last it was pointed out that Joseph Hall, of Bloomfield, Tipton, arrived at the truly scientific basis of puddling by what has been known as the "pig-boiling" process. By promoting intimate contact at correct temperatures between molten pig-iron and liquid iron oxides he had stumbled upon, after careful thought and experiment, the fundamental method of making wrought iron.

The re-actions, thermo-chemical in nature, between the oxygen of the fettling and refining oxides and the metalloids in the pig-iron are now more perfectly understood. Modern investigation has revealed the fact that these reactions are the basis of all open-hearth refining operations as used in the manufacture of steel and wrought iron.

Hall's process therefore lies at the root of present and future puddling processes and is not likely to be superseded. It is conceivable that further attempts may be made to produce wrought iron directly from poorly silicious ores, or by the decarburization of cheaply produced mild steel, but there are fundamental difficulties in the way of success, affecting the character of the crystalline structure and the related welding and fibreing properties of the resulting product.

At present the small open-hearth furnace for heating and melting the solid pig-iron, and for refining in contact with liquid fettling oxides, holds the field. It is indisputable that the small single-hearth-furnace, operated from one side only, hand-charged, hand-fired, hand-rabbled, and balled retains its position up to now as the best means of yielding a regular product and as the readiest method of dealing with varying qualities of pig-iron.

The "Double" furnace having a larger hearth, with two working sides and operated by two sets of puddlers, and with a firegrate common to the large hearth, has tempted many manufacturers, by reason of the apparent simplicity of the arrangement and the possibility of fuel saving and larger outputs per shift. For obvious reasons, the difficulty of two sets of puddlers "keeping-in-step" has led to irregularity of working and to poverty and lack of uniformity in the iron produced. (See Figs. 1 to 3 below.)

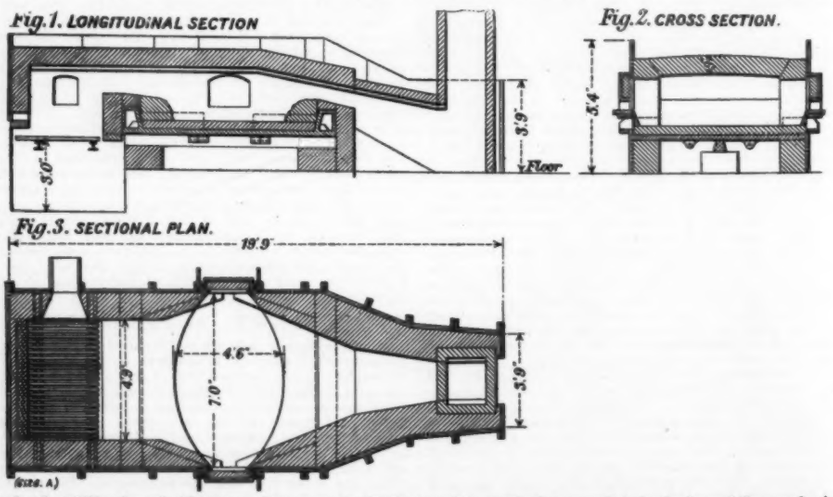
In the days immediately preceding the advent of the cheaper Bessemer and Siemens' steel processes, wrought-iron manufacture was dependent almost entirely on the practised judgment, unassisted by sufficiently available metallurgical knowledge. Good cold-blast and semi-cold-blast pig-iron was to hand, as was good fuel, cheap in price and plentiful. The scrap iron available was actually the scrap from genuine wrought iron—not the heterogeneous mixture which is nowadays so prevalent.

The call of the steel works claimed the men who were beginning to bring scientific knowledge into the domain of iron making, and to a very considerable extent, wrought iron manufacture has stumbled on without them. Machinery and plant, erected in times of comparative penury, was roughly designed and left in the hands of millwrights who, to their lasting credit, be it said, struggled manfully with the crudest of tools and lifting tackle, making the best of cumbersome gearing and mill trains whose foundations were often soaked in canal-flooded strata—often pulled about by adjacent mining subsidences.

Those were days when little besides the engine parts were machined. When bearings and shaft journals were put to work, not infrequently, direct from the foundry with little beyond a filing or chipping "fit." Where thick grease was the antidote to excessive "back-lash" in badly-shaped tooth forms in mill gearing, and when "wedge and liner" were the only correctives for casting misfits and inequalities. When boilers, fed with the slushy water from adjacent canals, of the 40 per cent. efficiency type and working at pressures little over 30 lbs. per sq. in., were the rule.

That such plants should still be running, in these days when the cry is for economy and efficiency, would not be understood were it not for the remembrance of the lean years which followed the advent of cheap steel, when wrought iron struggled for existence and ironmasters could not afford to speculate in the face of the prophecied early doom of the iron trade.

Thirty years or more have passed, and yet there are running, in some parts of the country, the same engines and mills as slowly struggled with puddled material forty or fifty years ago. Engines swallowing 40 lbs. or more steam per i.h.p. and mills grinding away under friction losses of 20 to 30 per cent. of the engine power, are unfortunately still to be found. That any concerns



* Paper read before the Staffordshire Iron and Steel Institute, Dudley, on November 22, 1919.

as are content to harbour under their well-ventilated roofs such relics of the past can live in the future is doubtful; yet there are a few remaining, grinding away metal and dividends. It is not surprising that the fearful spirits who neglected to avail themselves of effective machinery and plant should leave science out of their manufacturing methods. The old "rule of thumb" age is passing.

If, then, Hall's scientific puddling method is the fixed basis for wrought iron manufacture, the need of the future is a plant which shall utilise the principle with the least possible expenditure of fuel and labour. Three problems immediately present themselves to the investigator of the puddled iron question, and these may be said to rest on three dominant facts:—

1st. The Puddling Furnace as we now know it is one of the most wasteful of metallurgical furnaces, using more fuel per ton of product than any other continuous process.

2nd. The labour cost per ton is abnormally high, as is also the cost of furnace upkeep.

3rd. The rolling, shingling and material handling and transport plants are usually crude and excessively wasteful in power cost per ton of product.

The first problem is "How can the fuel bill be lowered?"

The second: "How can labour and repair costs be reduced?"

The third: "How can rolling and the other mechanical branches of the iron-making business be improved."

Compared with modern open-hearth steel-making furnaces the coal-fired puddling furnaces use from three to five times the quantity of coal per ton of product, the velocity of the hot gases across the hearth of a puddling furnace being above twice that in a well-designed steel furnace. The radiation losses in a puddling furnace and its waste heat boiler (or half boiler) amount to at least 20 per cent. of the heat energy of the coal burnt, or equivalent to say 5 to 7 cwts. per ton of puddle iron made, whereas in the steel furnace the radiation losses do not generally exceed 2 cwts. per ton of steel cast.

In a puddling furnace the radiation surfaces per cwt. of metal charged average 30 sq. ft. to 35 sq. ft., whereas those of the open-hearth steel furnace do not exceed 2 sq. ft. to 3 sq. ft. (up to the checker chamber inlets). Again, the bath or hearth area per cwt. of charge is in the puddling furnace about twenty times that of the steel furnace. It has been stated that the radiation losses per square foot of inner wall surface vary directly with the temperature head and as the square root of the gas velocity and inversely as the wall thickness, the relation being roughly expressed by the formula

$$R = \sqrt{V}\,(T_i^4 - T_o^4)$$

Where R = Radiation index.

V = Velocity of gases through furnace in feet per second.

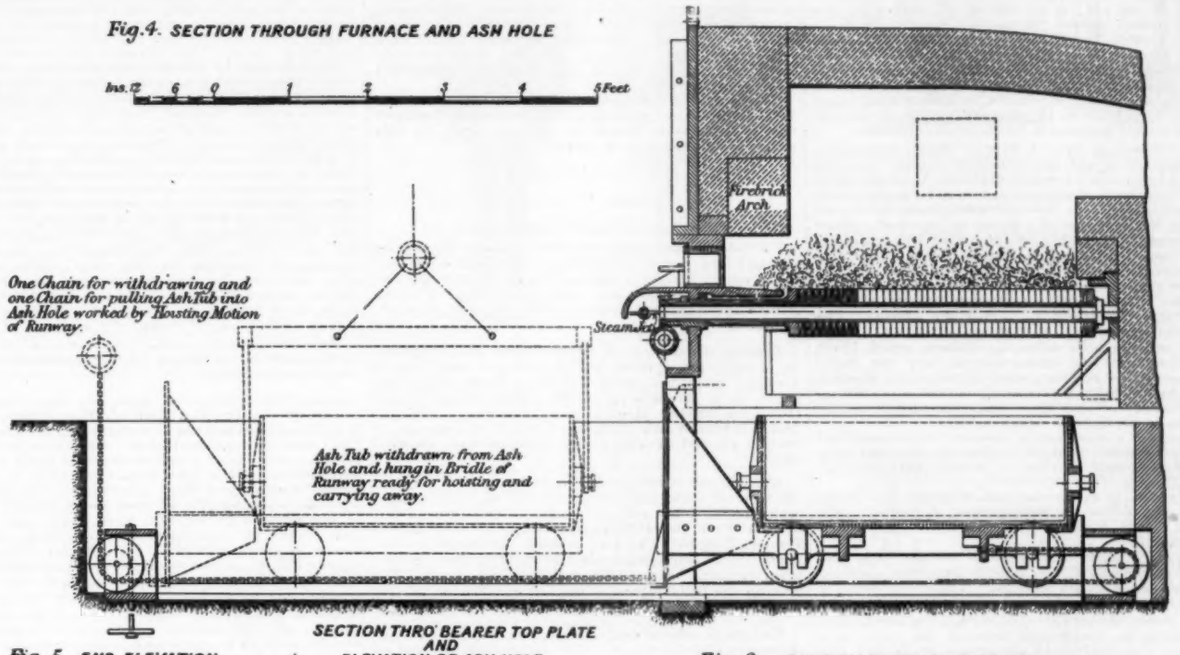
T_i = Absolute temperature at inner flame-side of wall of furnace.

T_o = Absolute temperature at outer cold side of wall of furnace.

A comparison between the value of the index R in the cases of puddling and steel melting open-hearth furnaces can be readily made, but for more exact calculations the formula of Professor J. W. Hinchley and the excellent radiation chart given by Sir Robert Hadfield and Mr. Sargent in their paper on Fuel Control read before the last meeting of the Iron and Steel Institute is the latest aid and of the greatest practical importance to all furnace designers and students.

The fact that to effect puddling in the open-hearth the area of the hearth required to puddle a ton of iron is twenty times that necessary to melt and refine a ton of iron and scrap in an open hearth steel furnace is of importance. This *shows very clearly that the small furnace is the hindrance to fuel economy*, its relatively

Fig. 4. SECTION THROUGH FURNACE AND ASH HOLE


Ins. 0 6 9 1 2 3 4 5 Feet
Fredrick Arch
One Chain for withdrawing and one Chain for pulling Ash Tub into Ash Hole worked by Hoisting Motion of Runway.
Steam Jet
Ash Tub withdrawn from Ash Hole and hung in Bridle of Runway ready for hoisting and carrying away.

SECTION THRO' BEARER TOP PLATE AND ELEVATION OF ASH HOLE.

Fig. 5. END ELEVATION.

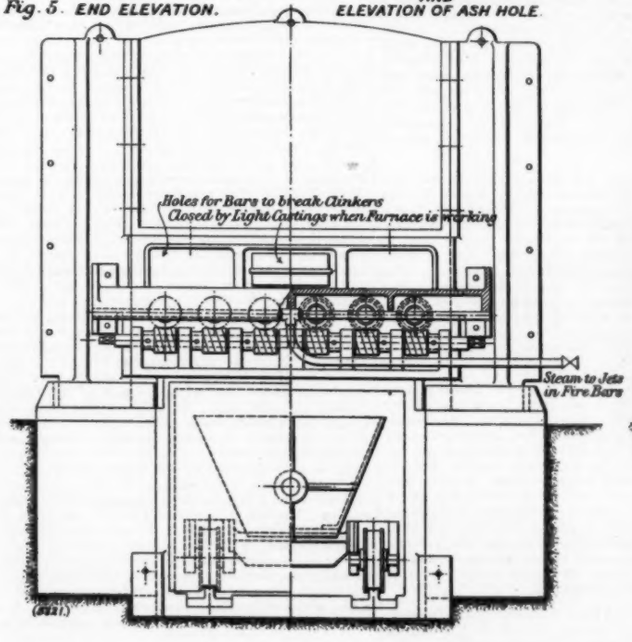
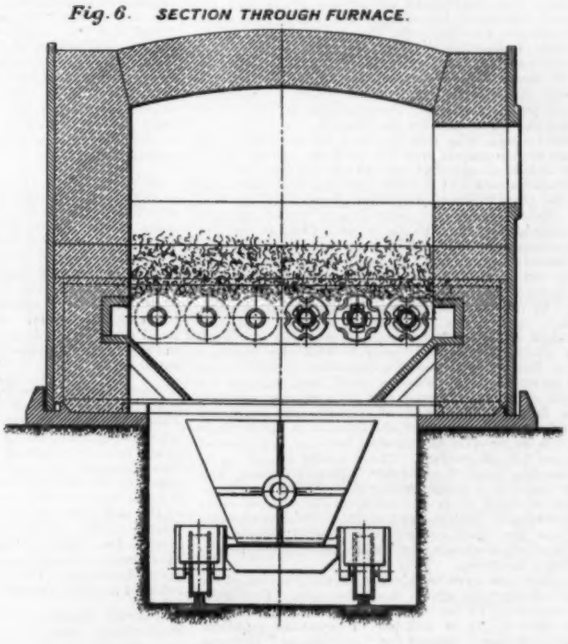


Fig. 6. SECTION THROUGH FURNACE.



large hearth being allied with excessive radiation areas. This explains the extent of the radiation losses, amounting to about 6 cwts. of coal per ton of puddled product.

The metallurgical requirements of the melting, superheating and refining of the metal charge is a fixed quantity, amounting to 4 cwts. to 5 cwts. of coal (of 12,000 B.T.U. to 13,000 B.T.U. calorific value) per ton of puddled iron. The necessity to keep the puddling furnace at between 1200° C. and 1450° C. fixes the radiation losses and these, along with the irreducible requirements for melting, refining, &c., demand the minimum use of 10 cwts. to 12 cwts. of coal per ton of product. In addition to this the heat energy escaping to the boilers and chimneys amounts generally to a further 18 cwts. to 20 cwts. of coal per ton of puddled iron, half of which is usually utilised in steam raising.

The "Double" puddling furnace already alluded to, though reputed to produce poor iron, does, by virtue of diminished radiation losses and the large output per hour and per ton of fuel, indicate one direction in which some further economy is possible, by means of the larger furnace. The limit to the size and weight of the ball in hand worked furnaces is, however, soon reached.

Improvements in Present Type of Small Furnaces.—The construction and proportions of a good coal-fired puddling furnace as at present used have been arrived at through long years of experience, and, as far as the hearth and heating chambers are concerned, these details are not likely to be substantially altered or improved. There is, however, a possibility of improving the grate and firebox, and of providing an efficient means for burning the poorer coals now so common.

In the grates usually provided the firebars are plain rolled flat or square bars, resting on bearers, with no arrangement for ensuring correct air spacing. The bars bend and twist in working and often enough become covered with adhering clinkers, which block the air passages. In attempting to clear the grates a number of bars may be pulled out together, allowing the hot fuel to fall into the ashpit and also permitting a large volume of cold air to enter the furnace to the detriment of the firebrick lining and roof.

In any case a considerable quantity of unburnt fuel falls into the ashpit, so much so that the ashes are often sifted and washed in order to recover the breeze or "gleads."

With a view to overcoming this difficulty and to the economizing of fuel the arrangement of furnace grate shown in Figs. 4, 5 and 6, page 805, has been designed by the author.

The grate consists of a series of tubular bars, perforated for air ejection, over which a number of specially chilled cast-iron discs are threaded. These form a kind of roller, grooved longitudinally so that when rotated by hand or power, clinkers are cracked and the burnt ashes accumulating in the troughs between the roller bars rolled into the ashpit, and the surface of the fuel bed disturbed whenever necessary. The discs are keyed to the bars and are rotated by the worm gearing on the outer ends of the tubes driving the bars.

The air required for combustion is forced through the tubes by steam jets and passes out through the perforations into the fuel bed and ashpit which is closed by the front plate of the ash removal wagon into which the ashes fall when the bars are rotated.

It will be seen that the air ducts between the grate discs are nozzle-shaped and also that the grates can be cleaned without opening the doors. Large clinkers or bats can be removed through the large holes provided above the grate in the firebox back plate. The problem of an efficient means of supplying a forced draught grate, suitable for the burning of such fuels as are now only too common in the Midlands and elsewhere, and also a simple and common-sense arrangement for the catching and removal of ashes has for some time occupied the author's attention, and the method shown is a studied attempt to improve the present wasteful and slovenly method.

The high velocity of the working gases in the small normal puddling furnace, together with the constant need for fettling and the impingement of iron oxide (basic) particles on the silicious (acid) roof, account for the rapid erosion and wear and tear of the puddling furnace linings. The cost of repairs and renewals of the refractory portions of the furnace is many times that of the larger open-hearth steel furnace, as expressed in cost per ton of product. There would appear to be an increasing need for "basic" bricks strong and durable, capable of withstanding the puddling temperature and unacted upon by the splashes of iron oxide which, as Messrs. Whitley and Hallimond have recently shown, are the main causes of the rapid destruction of silica and silica-alumina bricks in open-hearth melting and refining furnaces.

Many attempts have been made to use pre-heated air in puddling furnace grates and fireboxes. The difficulties attaching to its use are associated with the damper control. It is difficult to persuade puddlers that the "smother" desired for "nourishing" the iron at the critical period of refining can be dispensed with by using a diminished hot air supply controlled by a simple valve. Intelligent puddlers who have worked both gas and coal-fired furnaces say that the smother obtained in gas furnaces has not the same effect on the iron grain, as the heavier and "greasier" smother obtainable in the coal-fired furnace. In face of this it is not entirely safe to be scientifically dogmatic but to proceed warily when tackling the use of the reducing atmosphere so glibly talked about by gas furnace designers. It is probable that a certain steeliness of grain can be best obtained in the coal-fired furnace.

Generally, it may be stated that pre-heated air, obtained by robbing heat from the furnace walls or roof is only obtainable by increasing the rate of radiation from the walls and little actual economy can result. To be really useful the pre-heat should be obtained from a point between the furnace neck and the top of the chimney stack.

The application of gas-firing to small puddling furnaces has also been suggested, and mention should be made of a furnace built with a small producer at the firing end. A recuperator is placed under the furnace hearth for pre-heating the air. The furnace heating chamber has a double roof, the lower arch being perforated by a large number of small holes through which the pre-heated air is drawn by the chimney draught or assisted by a low pressure fan. The gas flows directly over the hearth, clinging to the roof, which, it is claimed, is thereby protected and its life prolonged. The result is a series of flame jets issuing from the roof and impinging on the charge in the hearth, and producing the turbulence which is by many considered necessary to effective combustion. By increasing the proportion of gas, sufficient heat is available to raise steam in attached waste-heat boilers.

This design is due to M. Chantraine, a distinguished Belgian furnace engineer, and it should be remarked that a number of re-heating furnaces built on this principle have given good results.

(To be continued.)

CATALOGUES.

Varnishes.—Insulating varnishes of the stoving and air drying kinds, anti-acid varnish for metal and wood surfaces, and a jointing compound in two grades are the subjects of special leaf catalogues received from British Insulated and Helsby Cables, Limited, Prescot, Lancs.

Drawing Apparatus.—A very complete series of drawing boards, set squares, Tee squares and many other drawing office, and some surveying, instruments, are shown in a catalogue from the Osda Branch of the Houghton-Butcher Manufacturing Company, Limited, Tudor Works, South Hackney, E.9. A separate price list and a leaflet showing vertical filing cabinets are also issued.

White Metal Bearings.—A bearing metal, No. 11, for the severest work, such as turbines, oil engines and aircraft engines, is the subject of a special catalogue issued by the Hoyt Metal Company, Limited, Deodar-road, Putney, S.W.15. The text repeats the caution, with much-needed emphasis, against overheating these metals when pouring a bearing. The rule is simple enough, viz., to keep the temperature at the lowest point at which the metal will run freely.

Tool Steels.—Some trade announcements and articles of practical information are published periodically under the title of the "Edgar Allen News," by Messrs. Edgar Allen and Co., Limited, Sheffield. One article in the No. 2 issue argues that, in all ordinary work, the high-speed twist drill is the most economical, after allowing for its extra cost, and states that high-speed steel does not expand more than carbon steel when heated. It is pointed out, on the other hand, that in drilling very hard cast iron, such as No. 1 White, or in attempting to drill manganese steel, it is best to use a flat drill of carbon steel.

Grinding Machines.—A cylindrical grinding machine is the chief feature of a catalogue from Messrs. Morton and Weaver, Cox-street, Coventry. This machine has a 5-in. swing, 25-in. length capacity between centres, 17 in. automatic travel of table and a cross feed of 3½ in. It can thus deal with a very large class of work from small engine pistons downwards. Evidently this kind of machine will soon be extensively made in this country. Some particulars are also included of a tool room or "Universal" grinder of the popular kind with hand traverse; a twist drill grinder; a series of lathes; milling, drilling and sawing machines; and a number of small tools.

Tooth Gears.—Double helical gears for large powers are the chief subject of a catalogue from the Power Plant Company, Limited, West Drayton, Middlesex, who also specialise in double helical bevel gears, straight gears, flexible couplings and Michell thrust bearings. A fine example illustrated is a double helical gear to transmit 23,000 h.p., for a battle cruiser. In this gear a small space is left at the apex of the teeth, but many of the mill gears of much smaller power have continuous double teeth. Apparently excellent work of this kind is still done with end-milling cutters, but the planing machine cutter with generating rolling motion is making great headway. The Sykes machine of this type is referred to, and is made by this firm.

Aircraft Engines.—A little booklet from Messrs. Rolls-Royce, Limited, 14, Conduit Street, W.1, recounts the experiences of a number of fighting and bombing raids in the late war, with a view to illustrating the reliability of the engines made by this firm. Mr. Boyd Cable is the writer of the booklet, and he is not much concerned with technical matters but rather with supplying an interesting record of events—in which he is thoroughly successful. He mentions, however, that a seven hours' continual flight is a remarkable performance for one of the best types of aircraft engines, and that a total of 150 hours' flying time without a complete overhaul is an equally good performance from another point of view. Both figures refer to engines in aeroplanes, not airships. Bombing, of course, always involved fighting, and in five weeks of Rhine raids we had 25 machines reported "missing" and shot down 34 German machines.

War Record.—Wolseley Motors, Limited, Adderley Park, Birmingham, send a 60 pp. quarto book illustrating their war products. The text is limited to explanatory matter for the illustrations. The products include automobiles in many forms, such as cars, lorries, ambulances, armoured lorries with revolving turret, anti-aircraft gun lorries, fast cars with Colt gun and with turret machine gun, field kitchens, workshops, &c. The firm also produced a large number of aeroplanes and aero engines, as well as airship transmission gear, air screws, shells, trench bombs and other war material. There are some interesting views of the workshops and of war scenes. The illustrations are handsomely printed in colour and the ordinary printing is distinctly above the average. In this, as in all similar engineering records, there is the most friendly acknowledgment of the good spirit shown by the employees generally in the war work.

Geared Turbines for Mill Driving.—With the growing accuracy of heavy toothed gears the turbine is steadily making its way into mill driving. A catalogue from Messrs. C. A. Parsons and Co., Limited, Newcastle-on-Tyne, describes several applications. At a mill in Stockport turbines of 2,300 brake horse-power, capable of overload to a total of 2,900 brake horse-power, operate on a steam pressure of 110 lb. with a superheat of 150 deg. F. High and low pressure turbines drive pinions, one on each side of a large helical gear wheel on a rope drum shaft. The reduction of speed is from 3,500 r.p.m. to 250 r.p.m., or 14 to 1. The drive is conveyed by ropes to 13 line shafts on six stories of the building. This installation has been in satisfactory operation for five years. Other cases are given, including the combination of an exhaust turbine with an older vertical compound engine of 2,100 i.h.p. in which the turbine on the same total steam consumption increases the power to a total of 3,000 i.h.p. The catalogue is prefaced by a short historical account of turbine development during the last 28 years and is altogether of exceptional interest.

Heavy Oil Engines.—A catalogue from Messrs. J. Samuel White and Co., Limited, East Cowes, Isle of Wight, describes a series of vertical engines working on "any class of recognised fuel oil." Two types are made—a heavy slow speed type for merchant ships and land installations, and a light high-speed type for special service, such as propelling submarines. The two-cycle principle is employed in all cases and is claimed to give 75 per cent. to 90 per cent. more power than a four-cycle engine of equal speed and dimensions, while the former is one-third less in total weight. The marine engines will run at two-thirds full speed for cruising, are without fly wheels if the cylinders are more than four in number, and in all cases are directly reversible by a partial turn of the cam shaft. The fuel is injected by pressure air, the average consumption ranging from 0·50 lb. to 0·45 lb. per brake horse-power per hour in the slow-speed engines and from 0·55 lb. to 0·525 lb. per brake horse-power per hour in the high-speed engines. Slightly more power per pound of fuel is obtained as the cylinders increase in diameter if the speed is low, and this rule is reversed if the speed is high; but the variation in the high-speed type is very slight. In the slow speed type the maximum fall of fuel consumption is 0·05 lb. per brake horse-power per hour as between cylinders of 7½ in. by 12 in. (150 brake horse-power) and 16 in. by 20 in. (950 brake horse-power). These figures, with other data given in the catalogue, indicate that the designs of various powers of two-cycle engines are worked out to very fine proportions, and in the case of stationary engines a choice may be very freely made as between one or several power units as local considerations dictate; for instance, where some sets are idle while others are working, or where the distribution of the machines involves extended power transmission. Engines suitable for land or marine use are made in six powers ranging from 150 brake horse-power to 950 brake horse-power with six cylinders; and another six powers from 100 brake horse-power to 635 brake horse-power are made with four cylinders. A third set of six powers are made for land use only ranging from 75 brake horse-power to 475 brake horse-power. On the whole the catalogue shows that within limits of 75 brake horse-power to 1,000 brake horse-power the two-cycle heavy oil engine, with its many advantages, is obtainable from British makers, of settled standard design and with interchangeable parts. The 18 sets contain a range of 17 powers. Engines of the light high-speed type are made with four, six or eight cylinders and in seven sizes ranging from 160 brake horse-power to 1,000 brake horse-power. The stroke is either 12 in. or 15½ in. in all sizes, and only three diameters of cylinders are used, viz., 9½ in., 11½ in. and 14 in. The weight per brake horse-power is, of course, lowest in the large sizes, being 61 lb. at 800 brake horse-power and 1,000 brake horse-power. The catalogue contains much information, and includes a fine series of line drawings printed to scale. A number of the engines are in both naval and commercial service.

The Late Professors A. Werner and A. Hurwitz.—The Federal Technical High School and the University of Zurich lost last month two famous teachers, both after long and severe suffering and neither of them old. The one was a chemist, the other a mathematician. Alfred Werner was known as a theoretical chemist, distinguished mainly in the field of affinity. Born in 1866 in Mülhausen, Alsace, he studied at Karlsruhe, Zürich and Paris, and became professor of chemistry at the Zürich Polytechnikum in 1892. He remained there till his death, in spite of many honourable calls to other Universities. A. Hurwitz was born in Hildesheim Hannover, in 1859, and was professor in Göttingen and Königsberg before he accepted the position at Zürich.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.

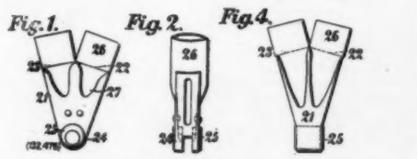
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

AERONAUTICS.

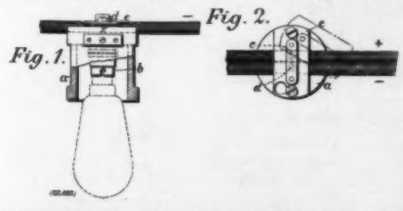
132,478. F. Handley Page, London. Aircraft Struts. (4 *Figs.*) December 4, 1915.—This invention relates to an improved construction of strut joint. According to the present invention, a joint for struts arranged in V to one another is formed of a blank of metal bent into box shape and secured by rivets or welded, and presenting sockets at its base to receive the struts, whilst its apex is adapted to receive a bearing member for a joint pin. The clip or union for the struts meeting in V is formed of a lower socket or box (Fig. 1) formed of a sheet of metal 22 (Fig. 3) stamped, or bent and welded, to form a slotted truncated triangular box, the base of which would be bevelled as at 221, 23, to present edges at right angles to the axis of the tubes to receive the struts, which should be connected at those places. At the point or apex of the V or triangular-shaped box this is rounded at 24 and has welded or riveted to it turned pieces of metal 25 to give the necessary bearing surface where the box abuts on the pin or the like on which it is supported. As shown in Fig. 1, the pin may be at right angles to the plane containing the struts,



or as shown in Fig. 4, may lie in the same plane. The blanks, such as 22, will be naturally shaped accordingly. Over each of the above mentioned bevel surfaces 221, 23, on the base or third side of the box 21, tubes 26 slotted out the necessary width of the box are slipped, and the ends 27 drawn down to fit close with ample area against the sides of the box, being preferably connected thereto by welding. Each of these tubular sockets for the strut may be of circular section or of stream-line or other section as desired, and in the preferred form, as shown, consist of a tube, the lower end of which is slotted, for instance, by a rectangular three-sided portion being taken out of it, the remaining convex fingers 27 being tapered and welded to the sides of the box. The struts may be connected to the sockets by pins or other suitable means of attachment. In the blank 22 from which such single or multiple rejoined parts are formed, suitable holes may be punched for lightness or for the reception of strut-receiving parts or brackets, meeting the same at different angles. (*Accepted September 24, 1919.*)

ELECTRICAL APPARATUS.

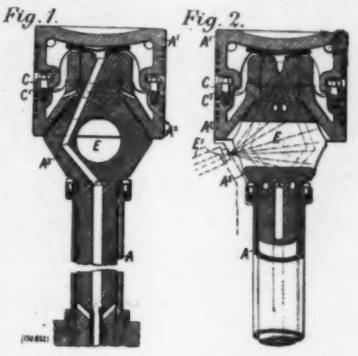
132,482. J. H. Collie, Birkenhead. Temporarily Connecting Lamps to Cables. (2 *Figs.*) August 13, 1918.—This invention relates to electric fittings of that type in which a connection can be easily and quickly made to insulated electric cables by pressing contact pins through the insulating cover on to or against the metal conductor therein for the purpose of supplying current temporarily or permanently for lighting purposes. According to this invention, the fitting comprises a block having a recess which is made large enough to receive a flanged holder fitted with piercing pins, the block being arranged to take a wire or other guard to protect the lamp. *a* is hollow



block or body member of substantially cylindrical form and has fitted to it a lamp holder *b*, of the bayonet type. The contacts are fitted to this holder in the usual manner, and are carried upwardly and terminate in points *c* and *d*, which are suitably insulated in the block *a*, and project into grooves therein. The cables are laid in these grooves and held therein by a plate *e* secured to the block *a*. In practise the fitting is applied to the cables by uncovering the points and pressing one cable down upon each of the points, thus establishing metallic contact between the respective cables and their points, to which the lamp can be fitted when desired. (*Accepted September 24, 1919.*)

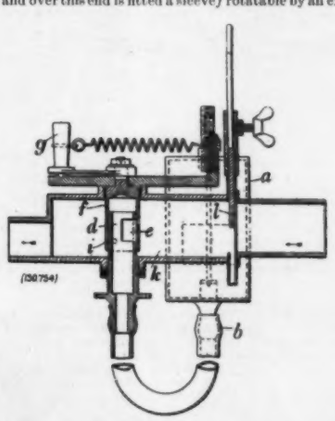
GAS ENGINES, PRODUCERS, HOLDERS, &c.

130,832. North British Diesel Engine Works, Limited, Whiteinch, Glasgow, and J. C. McC. Maclagan, Glasgow. Internal-Combustion Engines. (2 *Figs.*) September 23, 1918.—The invention relates to pistons and piston-rods for internal-combustion engines of double-acting Diesel type. The invention provides an improved piston having its under (or inner) side formed to the contour of the combustion space, substantially filling it when at that end of the stroke, and provided with an internal supplementary combustion space into which the fuel is directly delivered, the retardation of combustion owing to the flame being obstructed by the piston-rod being thus obviated. The piston rod A has formed on its upper end and adjacent to the under side of the piston a double conical enlargement A^3, the lower part of which is of substantially the same contour as the cylinder cover, whilst



the upper part carries a screwed tail-piece by means of which it is secured in a recess formed in the lower portion A^2 of the piston. The upper portion of the piston has at the bottom an inwardly-projecting flange C, resting on a flange C_1, formed on the top of the lower portion of the piston. The two parts of the piston are secured together by studs. The enlargement A^3 of the piston rod A has formed through it an aperture E forming a supplementary combustion space, and a fuel-injection device E^1 (shown by dotted lines) is so positioned in the cylinder wall that fuel is delivered into the aperture E in which the combustion takes place rapidly since there is no obstruction to the passage of the flame. (*Accepted August 20, 1919.*)

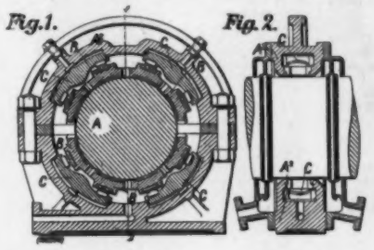
130,754. L. Barrow, King's Norton, Birmingham, S. Mc.A. Scott, King's Norton, Birmingham, and Cadbury Brothers, Limited, Bournville, Birmingham. Suction Gas Producers. (2 *Figs.*) August 6, 1918.—This invention relates to mechanically-propelled vehicles in which the engine is supplied with gas from a suction producer carried on the vehicle. The invention comprises a transversely slotted water or steam nozzle arranged in the path of the incoming air, in conjunction with a rotational and transversely slotted sleeve arranged to provide a variable fluid outlet. A float chamber *a* connected to a water supply at atmospheric pressure is in communication with a nozzle through a passage or pipe *b*, which may be controlled by a float actuated or other valve in the chamber *a*. The nozzle consists of a vertical tube *d* which, near its upper end, is formed with a wide transverse slot *e*, and over this end is fitted a sleeve *f* rotatable by an external



hand lever *g*, and formed with a narrow transverse slot *i*. The orifice formed by the slots is variable in size by movement of the lever. In the position shown the slot *e* is closed. On moving the hand lever in one direction the notch *i* in the sleeve uncovers a portion of the slot *e*. On moving the lever in the opposite direction the notch *i* uncovers another and larger (or smaller) portion of the slot *e*. Surrounding the nozzle is arranged an air passage *k*, the former projecting at right angles into the latter. At one end the air passage is provided with a slide *l* by which the volume of air flowing through the passage can be varied. The air flowing through the passage past the nozzle carries with it the requisite amount of water vapour and the proportion of either water vapour or air can be varied to suit different conditions of load or demand on the producer, the quantity of water vapour being proportional to the incoming air at all loads. (*Accepted August 20, 1919.*)

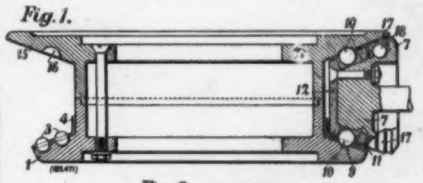
MACHINE AND OTHER TOOLS, SHAFTING, &c.

132,290. Vickers, Limited, Westminster, London, and Sir J. McKechnie, Barrow-in-Furness. Journal Bearings. (6 *Figs.*) June 8, 1918.—This invention relates to journal bearings of the type in which a series of separate bearing blocks or pads supported in a pivotal manner meet an opposing plain bearing surface of substantially the same radius of curvature, so as during working to cause a separating film of lubricant to be interposed between the bearing faces. According to this invention, the bearing blocks are arranged in balanced manner in one or more pairs upon one or more members rocking upon fulcrums carried by the casing of the bearing, preferably in recesses formed therein. A is the shaft and A^2 is the fixed casing of the bearing. To this casing is fulcrummed a number of yokes or rotating members C, C, having inwardly-projecting studs with rounded ends bearing against plates carried centrally by the bearing blocks B, a pair of these bearing blocks being provided for each yoke. To prevent the yokes from being carried round by the



shaft, each yoke is disposed in a recess formed in the fixed casing A^2. In the construction shown, there are four yokes and the fulcrums of the two lower yokes are stationary whilst the fulcrums of the two upper yokes are made capable of adjustment. (*Accepted September 24, 1919.*)

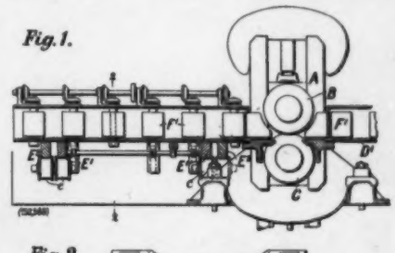
132,471. J. Julien, Withington, Manchester. Toothed Gearing. (3 *Figs.*) May 13, 1919.—This invention relates to toothed bevel gearing of that type in which one or both of the engaging members or wheels carry a series of balls located and retained within cavities or recesses, those balls on the one member being adapted to engage with recesses in the other member, whereby the motion of the driving member is directly transmitted to the driven member. According to the invention, a bevel thrust flange is provided upon one member, and is engaged by the other member at the opposite side of the latter to the driving side. One side of the bevel wheel 1 carries two series of driving balls 3 located in recesses and held in place by a retaining plate 4. Between these two series of balls 3 is a series of holes or recesses 9 made in the plate 4 and body of the wheel



and adapted to be engaged by a series of driving balls 10 carried by the pinion 7. These balls 10 engage in recesses in a seating ring 11 mounted on the pinion, and are held in place by a retaining cap or cage 12 secured on the end of the pinion by means of bolts. The bevelled face of the cap 12 is also provided with two circular series of cavities 14 (see Fig. 2) adapted to be engaged by the balls 3 on the bevel wheel. In order to take the lateral thrust created when power is being transmitted, and to prevent deformation of the shaft due to this thrust, the bevel wheel 1 has bolted to it a bevel flange or ring 15 having an annular groove 16 to receive the balls 10. The pinion 7 also carries a loose bevel ring 17 mounted upon a ball bearing 18 and engaging, by its outer face, with the face of the bevel flange 15. (*Accepted September 24, 1919.*)

MINING, METALLURGY, AND METAL WORKING.

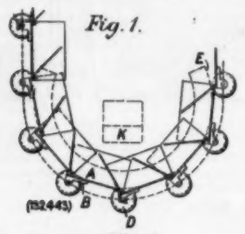
132,368. H. Crowe, Saltburn-by-the-Sea. Rolling Mills. (3 *Figs.*) September 19, 1918.—In a rolling mill in accordance with this invention, the bloom is gripped by vertical rollers disposed on frames capable of adjustment in a lateral

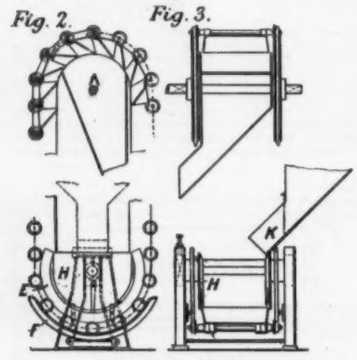


direction, at least one set of rollers being power driven. A is the housing, B the top and C the bottom roll of a cogging or "blooming" mill. Frames D^1 and D^2 are secured to beams E^1, E^2, respectively, the frame D^1 carrying a set of vertical power-driven rollers F^1 and the frame D^2 carrying similarly disposed

rollers F2, which need not be power driven. The beams E1, E2, can be moved laterally so as to bring the frames closer together or further apart by means of hydraulic cylinders. The beams E1, E2, are geared together by racks and pinions. (*Accepted September* 24, 1919.)

132,443. Babcock and Wilcox, Limited, and P. Paton, London. Improved Elevator. (4 *Figs.*) March 4, 1919.—The subject of this invention is an improved elevator of the type comprising a series of overlapping pivoted trays, the interiors of which face inwardly, the trays being arranged to travel in a path constituted by arcs joined by ascending and descending runs (vertical or inclined) the material being supplied into the arc at the lower end of the elevator, and delivered on arrival of the trays at the arc at the upper end. In accordance with the invention, provision is made for guiding the trays when travelling

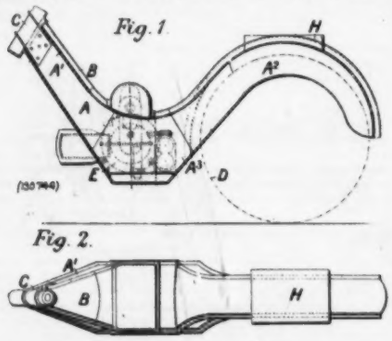




around the lower arc only. Each of the trays A is provided with bearing brackets B carried on a spindle on the ends of which are mounted track wheels D adapted to run on arcuate tracks E at the lower end of the elevator and guided by exterior guideways F, said tracks E and guideways F being sustained by a framing carrying the crossbar of the lower chain-guides, with provision for vertical adjustment of the tracks, &c., as by means of screws or other fittings, whereby to regulate the tension of the endless chains carrying the trays A. The framing carries, in addition, segmental side plates H serving to prevent side spilling. (*Accepted September* 24, 1919.)

MOTOR ROAD VEHICLES.

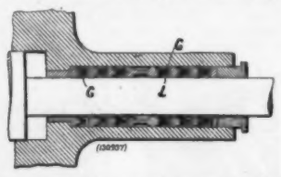
130,744. The D. F. and M. Engineering Company, Limited, Wolverhampton, and W. V. Ford, Wolverhampton. Motor Cycle Frames. (5 *Figs.*) August 3, 1918.—This invention relates to sheet metal frames for motor cycles and consists in forming a frame mainly of two vertical sheets which are spaced apart and attached to the steering head at their forward ends, and from thence slope downwards and then pass at either side of the back wheel to form the valances of the rear mud guard, a suitable cover being provided to form the top of the mud guard. The main portion of the frame is made up of two sheet metal sides A disposed in vertical planes, and these are covered with a sheet metal roof B. The forward portion A^1 of the frame slants downwards rearwardly from the ball-head or steering-spindle socket C; the rear portion A^2 of the frame



curves over the axis of the rear wheel D (shown by a broken line circle, Fig. 1); and the middle portion A^3 of the frame, which is widened out to receive the engine and gear-box, is curved at its upper side to join tangentially into the upper sides of the portions A^1, A^2, respectively. The sides of the portion A^1 of the frame slant towards one another in a forward direction, and the ball-head C is riveted thereto. The engine E and gear-box are carried upon a baseplate. The liquid fuel tank, and if desired the oil tank also, may be carried between the portions A^1 of the frame sides. No provision is shown for carrying the seat, as this may be of any convenient character. A sheet metal platform H is shown as built upon the portion of the frame which curves over the rear wheel, and this may be utilised as a luggage carrier or for carrying the seat. The frame may be connected with the rear axle in any convenient manner. (*Accepted August* 13, 1919.)

PUMPS.

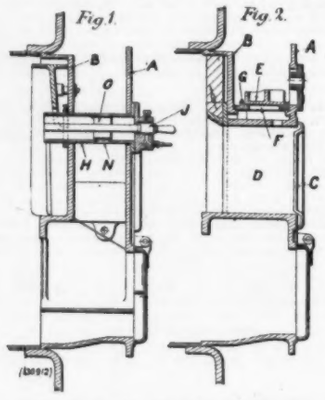
130,937. E. A. Thomson, Finchley, London. Packing. (2 *Figs.*) April 11, 1919.—This invention relates to packing for the rods, spindles, pistons or plungers of pumps. According to the present invention, in which cupped rings G are employed in combination with expansion rings L of elastic material, such as rubber, rubber or leather substitute, and with a bearing piece



of suitable shape to support the same, the elastic expansion rings L within the cupped rings are made with lateral wings that extend on the outside into contact with the interior wall of the stuffing-box and on the inside into contact with the piston or other rod, the surfaces of such extensions being shaped to fit against the corresponding surfaces of the cupped rings and of the bearing piece. (*Accepted August* 20, 1919.)

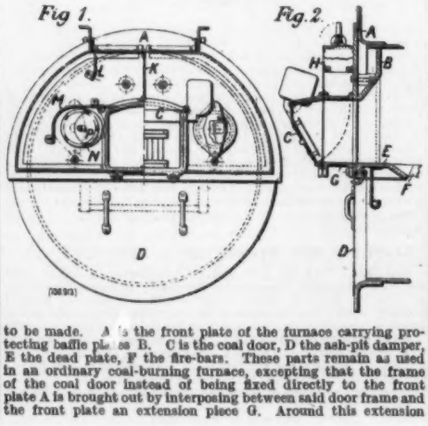
STEAM ENGINES, BOILERS EVAPORATORS, &c.

130,912. C. Zulver, London, and L. E. Smith, South Shields. Furnaces. (3 *Figs.*) February 24, 1919.—This invention relates to furnace fronts capable of use when burning either liquid or solid fuel. According to the present invention, instead of mounting the liquid fuel burner or burners on the fire door, the burner or burners is or are kept clear of such door, or of the fire opening, for which purpose each burner is arranged in an air-control tube extending through holes of corresponding shape in the front and back plates of the forced-draught fronts. These tubes open at their inner ends into the furnace at positions exterior to the fire-opening, and are provided at the parts between the said front and back plates with air inlets controlled by suitable dampers or valves. This enables coal and oil to be burnt in conjunction if desired, and also reduces the time required



for converting from coal to oil working, or *vice versa*, as no pipes or connections have to be disconnected. A, B, are the front and back plates of the forced-draught front. C is the fire door and D a tubular fire opening closed by the door C and extending through the plates A, B. E is a valve actuated by a handle E^1 and controlling apertures F, which are formed in the upper peripheral wall G of the forced-draught front. H is one of the tubes, in each of which a burner J is mounted, and which extends through circular holes in the plates A, B, its inner end opening into the furnace in a position exterior to the fire-opening D. The tubes H, H, are each provided with an annular series of air inlets N, N, arranged to open into the space between the plates A, B, and controlled by a tubular sliding damper O, which may be operated by means of a suitable handle or handles passing through holes in the burner holder. (*Accepted August* 20, 1919.)

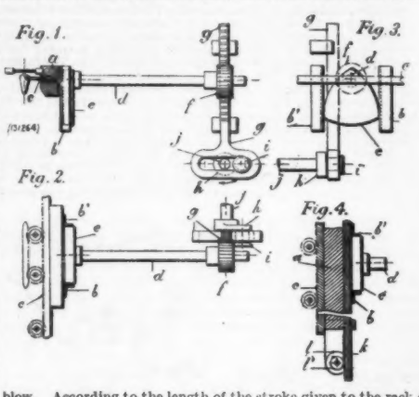
130,913. H. A. Thompson, North Shields, C. Zulver, London, and L. E. Smith, South Shields. Furnace Fronts. (4 *Figs.*) February 24, 1919.—This invention relates to steam boiler and other furnace fronts, and has for its object to provide a front that enables either solid or liquid fuels to be used, and to change over quickly from one kind of fuel to the other without having to disconnect any fittings or pipes to enable the change



to be made. A is the front plate of the furnace carrying protecting baffle plates B. C is the coal door, D the ash-pit damper, E the dead plate, F the fire-bars. These parts remain as used in an ordinary coal-burning furnace, excepting that the frame of the coal door instead of being fixed directly to the front plate A is brought out by interposing between said door frame and the front plate an extension piece G. Around this extension piece is built a casing or chamber H, which is secured to the extension piece and the front plate A. The casing H may be furnished with a central vertical dividing plate K to make the two sides of the chamber independent of each other. L and M are guide and radiating vanes for guiding and heating the air which enters the casing H and ensuring that the air shall pass over the whole of the surface of the front plate A before entering the air tubes N. These air tubes are inserted through holes in the front of the casing H, and in the front plate A, as well as in the baffle B, and are secured to the front of the casing H. An oil burner P passes through the centre of each tube N. (*Accepted August* 20, 1919.)

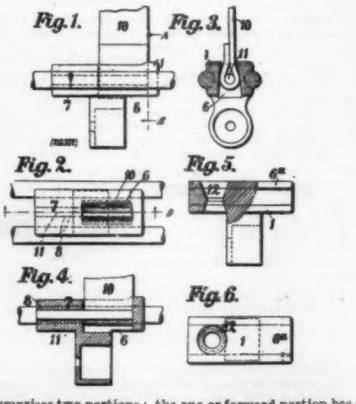
TEXTILE MACHINERY.

131,264. A. David, St. Etienne, France. Shuttle-Driving Mechanism. (4 *Figs.*) May 31, 1919.—This invention relates to shuttle-driving mechanism for weaving looms. At any point along the length of the batten *a*, and either on the inside or on the outside of the loom, two partitions *b* and *b1* are attached to the rack *c*; a transverse shaft *d* carries at one of its ends, a triangular cam *e*, which is contained in the cage formed by the partitions *b* and *b1*. It receives an oscillatory movement from a pinion *f* gearing into a rack *g* which receives an alternating movement by means to the crank *h* and the pivot *i* mounted on the end of a shaft *j*. This shaft *j* revolves in the proportion of one revolution to two blows of the batten, and the cam *e* will alternately carry the rack *c* to the right on one blow and to the left on the other



blow. According to the length of the stroke given to the rack *g* by the movement of the pivot *i* a more or less prolonged oscillation of the cam *e* will be obtained and the ratios of duration of the strokes and repose of the rack *c* are thus obtained and practically regulated. In order not to have cams *e* of too minute a size for the small widths of ribbon and cams of too large a size for large widths of ribbon, the rack *c*, in these battens, will be driven by a bar *k* (see Fig. 4) connected to it at each end by reducing pulleys *l* and *l1*, and the walls of the cage *b*, *b1*, will be fixed then to the bar *k*, and they will impart to the rack *c* a stroke in the inverse direction, which is proportionally different to that of the bar *k* with relation to the different diameters of the pulleys *l* and *l1*. (*Accepted August* 27, 1919.)

132,322. A. Newton-Smith, Westminster, London. Pickers of Looms. (11 *Figs.*) September 6, 1918.—This invention has reference to pickers of the kind mounted to slide to and fro' on races that comprise rails or grooves and of the kind in which the picking effort is applied as nearly as is possible in line with the shuttle. In a picker of the kind herein referred to, in accordance with this invention, the body of the picker between its mountings comprises two portions, one or other of which constitutes a part in the connection of the picker with the picking stick, the one portion having a longitudinal and tapered slot in which the picking strap is held by a pin or peg, and the other portion having a hole in which a part of or on the picking stick engages. 1 is the body of the picker, the opposite side faces of which are formed with grooves that are engaged, respectively, by rods which constitute the picking spindle. The picker



body 1 comprises two portions; the one or forward portion has a longitudinal slot 6 and the other or rearward portion 7 is solid. The slot 6 is taper and the solid portion 7 has a hole 8 extending longitudinally therethrough and entering the slot 6 at its rearward end. 10 is the picking strap. The picking strap 10 is attached to the picker by bending a portion back on itself, passing the bight so formed down into the slot 6 and passing a pin or peg 11 through the hole 8 into and longitudinally of the slot 6 and between parts of the strap 10 contained therein. In Figs. 5 and 6 the forward portion 6s of the picker body is solid and the rearward portion 7 is formed with a hole 12 that is countersunk or coned inwardly from its upper and lower ends. Direct connection of the picker with the picking stick is effected by a part of or on the picking stick engaging the hole 12. (*Accepted September* 24, 1919.)